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FINAL WORK PLAN FOR REMEDIAL INVESTIGATION SITE 4 NCBC GULFPORT MS
6/25/2004
TETRA TECH NUS

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TtNUS/TAL-04-041/9666-3.2

25 June, 2004

Project Number N9666

Commander, Southern Division
Naval Facilities Engineering Command
ATTN: Mr. Art Conrad (Code ES32)
Remedial Project Manager
2155 Eagle Drive
North Charleston, South Carolina 29419-9010

Reference: Clean Contract No. N62467-94-D0888
Contract Task Order No. 0283

Subject: **Final** Work Plan For Remedial Investigation At
Site 4 – Golf Course Landfill

Dear Mr. Conrad:

Tetra Tech NUS, Inc. is pleased to submit the enclosed **Final** Work Plan For Remedial Investigation at Site 4 – Golf Course Landfill At The Naval Construction Battallion Center Gulfport, Mississippi. If you have any questions regarding this submittal or require further information, you may contact me at (850) 385-9899.

Sincerely,

Robert Fisher, P.G.
Task Order Manager

/bh

Enclosure

c: Gordon Crane
Bob Merrill, MDEQ
Debbie Wroblewski (Cover Letter Only)
Mark Perry(Unbound)

Rev. 1
06/25/04

Final Work Plan for Remedial Investigation at Site 4 – Golf Course Landfill

NAVAL CONSTRUCTION BATTALION CENTER
GULFPORT, MISSISSIPPI

Southern Division
Naval Facilities Engineering Command

Contract Number N62467-94-D-0888
Contract Task Order 0283

June 2004

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ACRONYMS AND ABBREVIATIONS

ARARS	Applicable or Relevant and Appropriate Requirements
CADD	Computer Automated Drafting and Design
CLEAN	Comprehensive Long-Term Environmental Action Navy
COC	Chain-of-Custody
CTO	Contract Task Order
DCE	Dichloroethene
DI	Deionized
DOQQ	Digital Ortho Quarter Quads
DMP	Data Management Plan
DPT	Direct Push Testing
DQO	Data Quality Objective
DVC	Data Validation Coordinator
DVM	Data Validation Manager
EDD	Electronic Data Deliverable
EGIS	Environmental Geographic Information System
EM	Electronic Magnetic
EPA	Environmental Protection Agency
ERA	Ecological Risk Assessment
FOL	Field Operations Leader
FS	Feasibility Study
GIS	Geographic Information System
HHRA	Human Health Risk Assessment
HLA	Harding Lawson
HO	Herbicide Orange
HPCDD	Heptachlorodibenzo
HYPCDD	Heptachlorodibenzo-p-dioxin
IAS	Initial Assessment Study
IMS	Information Management System
IR	Installation Restoration
ILAN	Local Area Network
LIMS	Laboratory Information Management System
MCLS	Maximum Contamination Level Screening
MDEQ	Mississippi Department of Enivornmental Quality

MEK	Methyl Ethyl Ketone
NA	Natural Attenuation
NAD	North American Datum
NCBC	Naval Construction Battalion Center
NEESA	Navy Energy and Environmental Support Activity
NGVD	National Geodetic Vertical Datum
NTUS	Nephelometric Turbidity Units
OCDD	Octachlorodibenzodioxin
PARCC	Precision, Accuracy, Representativeness, Comparability, and Completeness
PPB	Parts Per Billion
PPQ	Parts Per Quadrillion
PECDD	Pentachlorodiphenodioixin
PMO	Project Management Organization
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
RAB	Restoration Advisory Board
RFD	Reference Doses
RI	Remedial Investigation
RSD	Risk Specific Doses
RPM	Remedial Project Manager
SDG	Sample Delivery Group
SMC	Sample Management Coordinator
SOUTHDIV	Southern Division Naval Facilities Engineering Command
TCDD	Tetrachlorodibenzo-p-dioxin
TEQ	Toxicity Equivalence Quotient
TFMR	Technical Financial Monthly Report
TOM	Task Order Manager
TSSDS	Tri-Service Spatial Data Standards
TtNUS	Tetra Tech Nuclear Utility Services
SRTS	Sediment Recovery TRAPS
USGS	United States Geological Survey

1.0 INTRODUCTION

Tetra Tech NUS (TtNUS), under contract to the U. S. Department of the Navy, Southern Division, Naval Facilities Command (NAVFAC EFD SOUTH), has prepared this Remedial Investigation (RI) Work Plan for Site 4 at the Naval Construction Battalion Center (NCBC) in Gulfport, Mississippi. This work plan was prepared under the comprehensive Long-term Environmental Action Navy (CLEAN) III, Contract No. N62467-94-D-0888.

The Contract Task Order (CTO) 283, requests that TtNUS conduct:

Project Management

Community Relations

Work Plan

Field Investigations

Laboratory Analyses

Data Management

RI Report

Feasibility Study (FS)

Decision Documents

This Work Plan describes the field activities, laboratory analyses, and data management to be performed for the Site 4 RI. The purpose of this Work Plan is to guide the efforts to identify and delineate the impact to environmental media at Site 4 - Golf Course Landfill due to past waste handling practices. The following sections outline the site history and the objectives, purpose, and scope of the RI Work Plan.

2.0 SITE BACKGROUND AND HISTORY

NCBC Gulfport is located in the western part of Gulfport, Mississippi, approximately 2 miles from the Gulf of Mexico. Gulfport is located in Harrison County, in the southwestern corner of the state (Figure 2-1). The base occupies 1,100 acres and has an average elevation of 30 feet above mean sea level. The only significant variations in topography occur at the storage area where linear piles of bauxite range from 30 to 40 feet above grade. The bauxite piles are being removed from the base.

Site 4 is a former 4.0 acre landfill located northeast of the intersection of 7th Street and Colby Avenue and is adjacent to the driving range at the Pine Bayou Golf Course (Figure 2-2). As shown on Figure 2-2, the northern boundary of the landfill is adjacent to Canal No. 1. The landfill was operated from 1966 until 1972 and was the only operating landfill on the base at that time. Waste material was disposed of in trenches, burned daily, and then backfilled. Most, if not all, of the solid waste and some of the liquid and chemical waste generated at the installation were disposed of at Site 4 during the period of landfill operation (*Initial Assessment Study*, Envirodyne Engineers, Inc., 1985).

As indicated in the *Initial Assessment Study* (Envirodyne Engineers, Inc., 1985), as much as 200,000 gallons of waste liquids were disposed of at the site including; fuels, oils, solvents [(MEK), toluene, xylene], paints, and paint thinners. In addition, 16,000 tons of solid waste was disposed at the landfill. Building and infrastructure debris were disposed at the site following Hurricane Camille in 1969.

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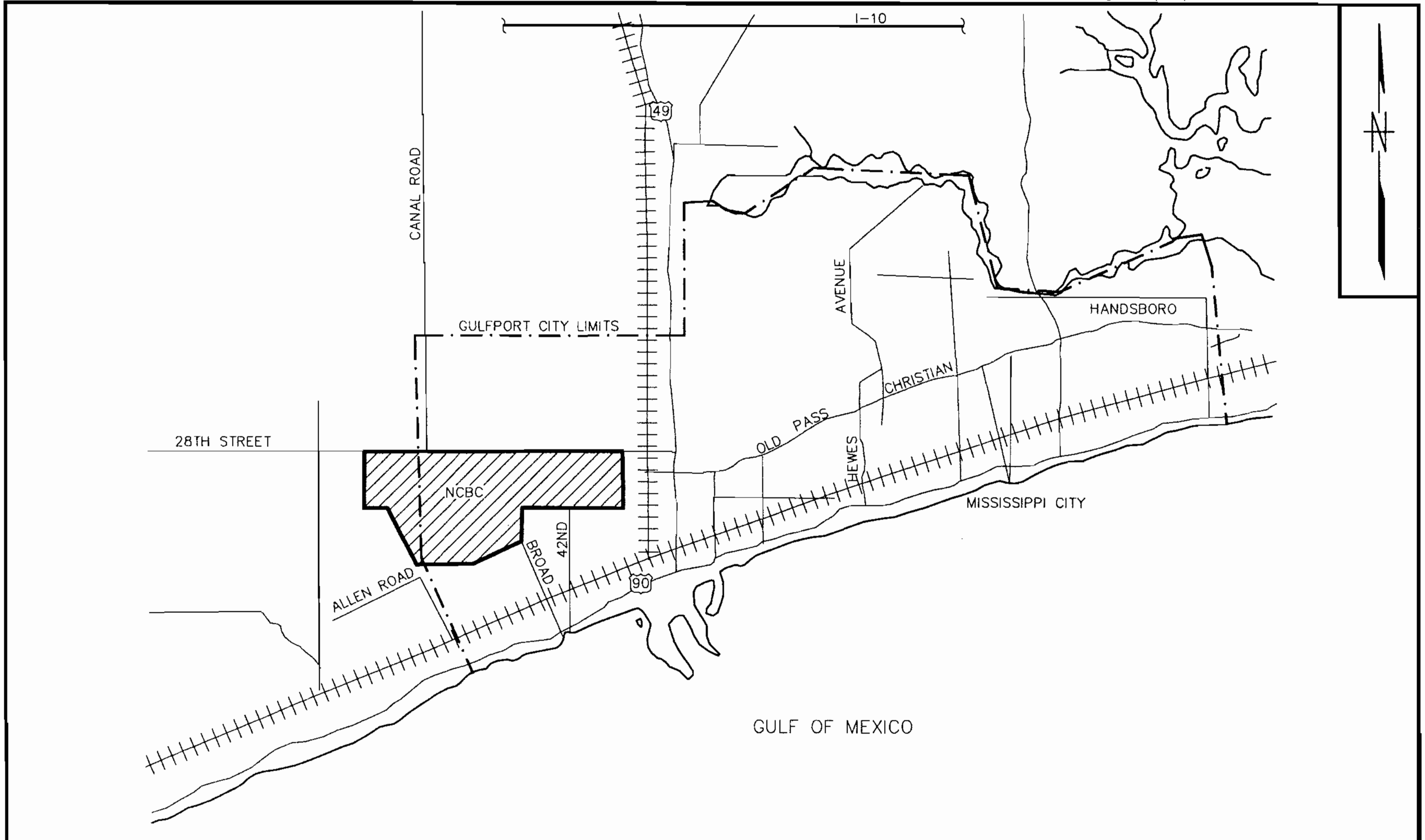

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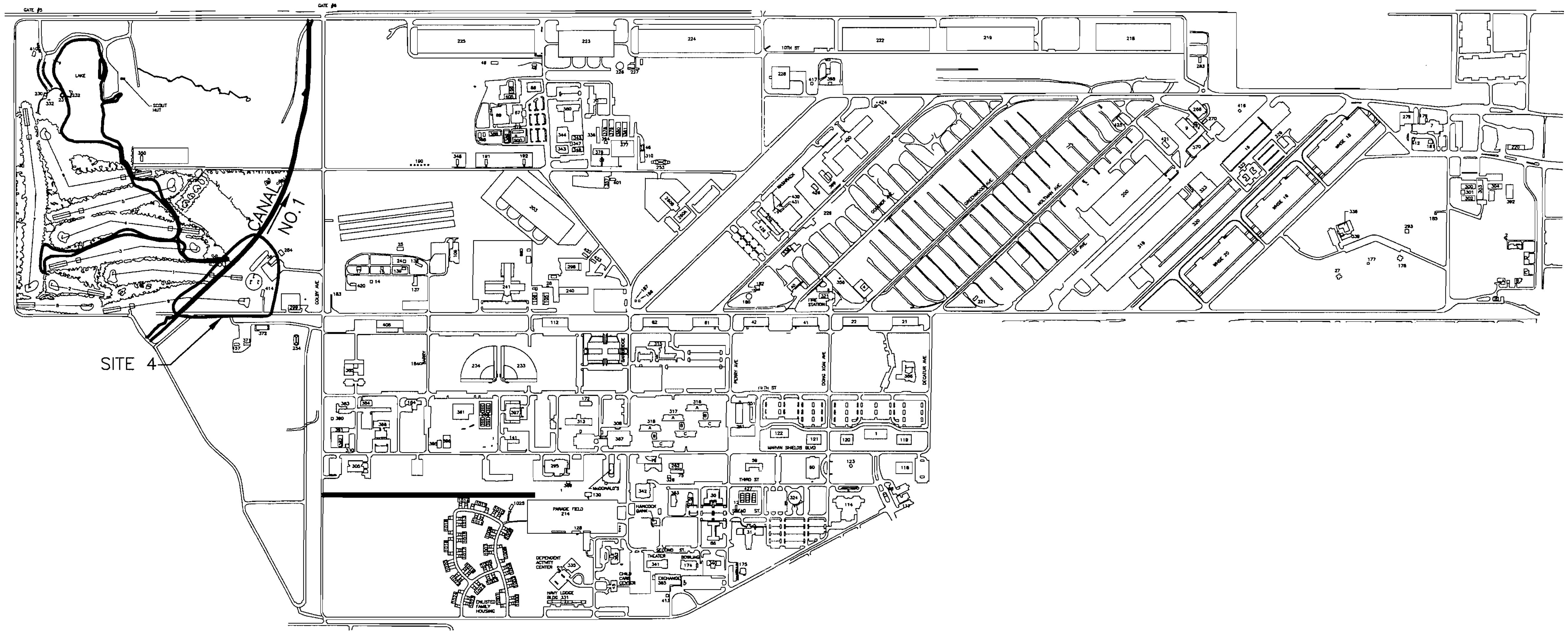

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3.0 PREVIOUS INVESTIGATIONS

The following is a discussion of the previous investigations at Site 4 from the Initial Assessment Study through the latest investigation, Groundwater Monitoring. This section will also discuss potential pathways of contaminant migration and identify preliminary response objectives and remedial action alternatives.

3.1 PREVIOUS INVESTIGATIONS

Five previous investigations have been undertaken at Site 4, as discussed below. These investigations have included subsurface soil, groundwater, and sediment sampling, but were not complete for the purposes of a remedial investigation. Results of these studies revealed a wide range of contaminants above Mississippi Department of Environmental Quality (MDEQ) Tier 1 Screening Levels for the respective media.

1985 Naval Energy and Environmental Support Activity (NEESA) - *Initial Assessment Study of NCBC Gulfport* – The initial assessment study (IAS) identified and assessed sites at NCBC Gulfport that were potential threat to human health and the environment. The IAS included:

- A records search
- On-site survey, including geophysics to define site boundaries
- Site ranking
- An outline for the Confirmation Study

1987 Harding Lawson (HLA) - *Confirmation Study* - Surface water, groundwater, and soil samples were collected from locations at Site 4. The sampling locations were on the south and west sides of Site 4, under the assumption that surface water and groundwater flowed to the south. This assumption was incorrect; therefore the sample locations were up- or cross-gradient of the source areas. No contaminants were detected at concentrations exceeding the action levels in the groundwater samples collected for this investigation.

1995 (ABB-ES) - *Surface Water and Sediment Delineation Study* - Surface water, sediment, seep, and groundwater samples were collected from the ditches in and around Site 4. Four shallow monitoring wells were installed adjacent to Canal No. 1 to evaluate the groundwater discharging to seeps observed along the bank of Canal No. 1. Dioxins were detected at concentration ranging from 0.65 parts per quadrillion (ppq) up to 26.4 ppq in the groundwater samples collected from these wells. The results from well GPT-4-5 indicated vinyl chloride at 37 parts per billion (ppb), 1,2-Dichloroethene (DCE) at 180 ppb, and trichloroethene at 4.7 ppb. Groundwater potentiometric surface maps confirmed near surface groundwater flow was to the northwest, and not to the south as had been previously thought. A seep sample collected from the bank of Canal No. 1 produced a dioxin TEQ result of 82.9 ppq with 14.1 ppq of Tetrachlorodioxin (TCDD). The presence of tetrachlorodioxin TCDD and pentachlorodiphenodioxin (PeCDD) in the seeps can be an indication that herbicide orange (HO) is the source of the detected dioxins and furans.

1997 Morrison-Knudsen – (DPT) sampling of soil and groundwater near subsurface magnetic anomalies identified during a geophysical investigation. Arsenic concentrations above Tier 1 Risk Screening levels for soil were detected, as well as low levels of dioxins and furans. The TCDD congener was not detected. Activated carbon traps were installed to intercept groundwater discharging from seeps into Canal No. 1.

1998 HLA - *Groundwater Monitoring Report* - An in depth study of groundwater conditions was conducted at Site 4, with a focus on the potential for dioxins and furans. DPT dioxin results at Site 4 indicated widespread, low levels of dioxin and furan congeners in the groundwater. The main congeners observed in the DPT samples were octachlorodibenzodioxin (OCDD) and heptachlorodibenzo-p-dioxin (HpCDD), indicating that HO is not a likely source. Groundwater samples from Site 4 produced only low level dioxin results that were all well below the (MCLs). No TCDD was reported from any of the ground water samples.

Several (VOCs) were reported in DPT samples above MCLs at Site 4, including vinyl chloride (21 ppb), 1,2-Dichloroethene (DCE) (220 ppb) and trichloroethene (TCE) (12 ppb). The DPT samples with exceedances were collected near monitoring well GPT-4-5, which had vinyl chloride and DCE above MCLs in 1997 (ABB-ES, 1998). Groundwater well samples collected from the area of the DCE and vinyl chloride (VC) plume identified by the DPT samples confirmed the levels of VC (65 ppb), 1,2-DCE (540 ppb), TCE (22 ppb), and 1,1,2-(TCA) (9 ppb). The screen of well GPT-04-14 was set at a depth of 35 feet, which is on top of silty/sandy clay-bearing strata. The VOC plume is in the lower area (20 to 35 feet bls) of the surficial aquifer near the clay-bearing zone. The presence of these VOCs is likely due to the disposal of chlorinated cleaning compounds reported to have taken place at this landfill. The age of these activities (1966-1972) and the ratios of breakdown chemicals (vinyl chloride) to parent chemicals (1,1,2-TCA) suggest that significant degradation has taken place.

The 6-month hydrologic analysis showed groundwater from Site 4 is at a higher elevation than the surface water in Canal No. 1, indicating groundwater is typically discharging the canal. Seep samples collected at Site 4 (two rounds) have confirmed the activated carbon traps are intercepting the low level dioxin contamination present in groundwater before it enters Canal No. 1. No other remedial and/or removal actions have taken place at the site.

3.2 POTENTIAL PATHWAYS OF CONTAMINANT MIGRATION

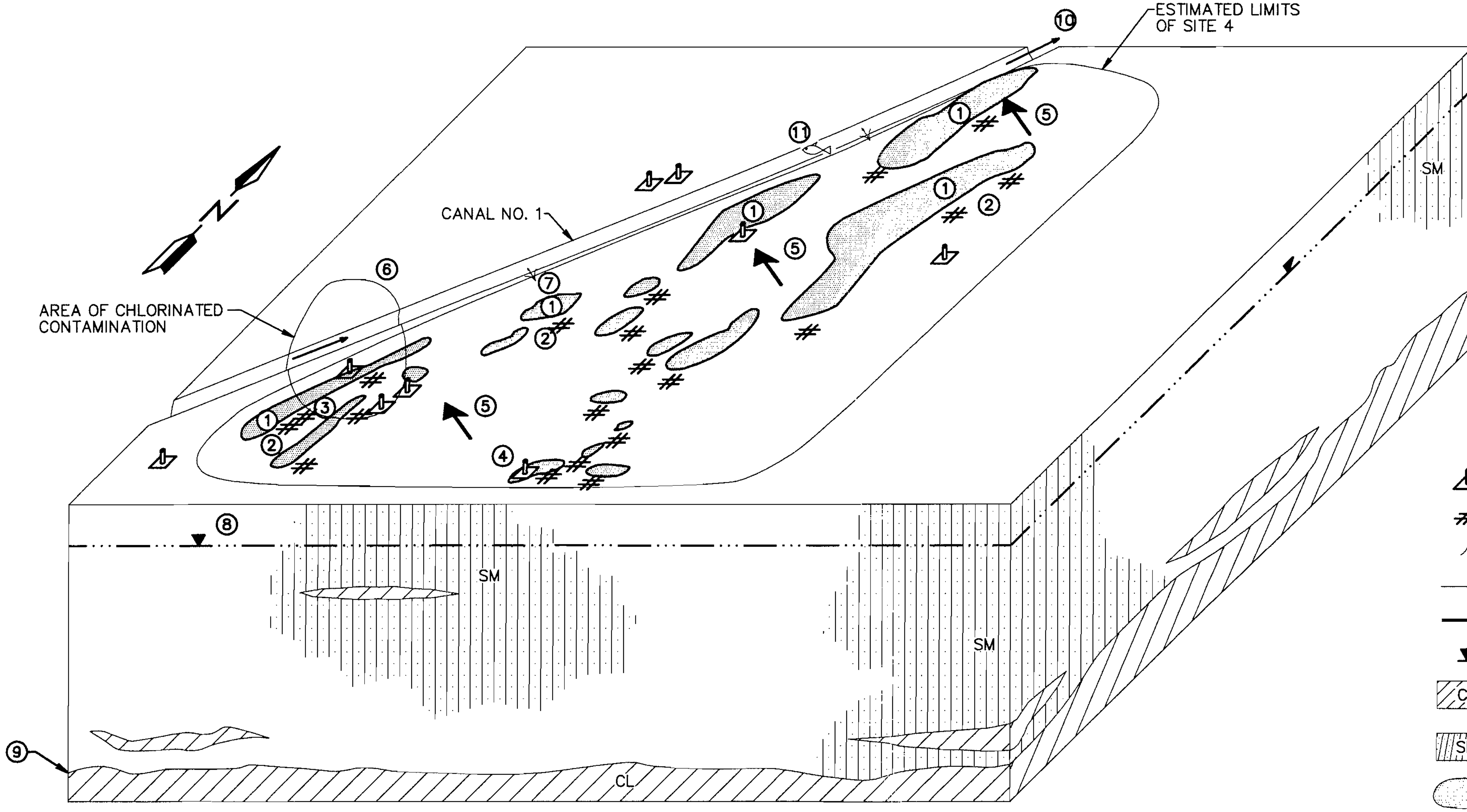
Previous investigations have identified the following potential sources of contamination at Site 4:

- Liquid and solid wastes disposed of in the landfill, and
- Backfilled incineration by – products.

Topography at site 4 is relatively flat and the ground surface is primarily fill dirt and native sand with sparse vegetative cover. Canal No. 1 runs along the west side of the landfill. The surface water flow directions are to the north where Canal No. 1 eventually leaves the base at 28th Street. Seeps have been observed discharging from the east (landfill) side of the drainage ditch that runs along the west side of the site. The groundwater at Site 4 is somewhat deeper than the surrounding area due to several feet of landfill cover. The cover material is a fine to medium sand with little silt allowing infiltration or seepage into the landfill. The top of the local confining clay layer was encountered at depths of approximately 30 feet bgs.

Potential contaminant release mechanisms at Site 4 include the mobilization of contaminants from wastes buried in subsurface soil tolocal groundwater by infiltration of precipitation and dissolution of soluble contaminants. Soluble constituents can be transported to the water table by rainwater infiltration, and may continue to migrate downgradient to the south and southwest of the landfill. Transport is affected by the chemical and physical properties of both the soil and the contaminants. The dissolved contaminants in groundwater may migrate downgradient with the natural flow of groundwater and discharge as seeps to Canal No. 1. Figure 3-1 displays the site conceptual model that illustrates these potential contaminant migration pathways.

Currently erosion and overland transport of particulate matter from site surface soil do not appear to be important transport mechanisms at Site 4 due to the presence of several feet of clean fill covering the site.



EXPLANATION

- EXISTING MONITORING WELLS
- BURIED METAL DEBRIS
- SEEPS FROM BANK OF CANAL NO. 1
- SURFACE WATER FLOW DIRECTIONS
- GROUNDWATER FLOW DIRECTION
- GROUNDWATER LEVEL
- CL — INORGANIC CLAY OF LOW TO MEDIUM PLASTICITY
- SM — FINE AND MEDIUM SAND WITH SOME SILT
- APPROXIMATE EXTENT OF DISPOSAL CELLS
- BIOTA
- 9 — TEXT CUE

SOURCES AND POTENTIAL RELEASE

* SOLID WASTE FROM BASE DUMPSTERS
* LIQUID WASTES GENERATED ON BASE
  - FUELS, OILS, SOLVENTS (MEK, TOLUENE, XYLENE), PAINTS, AND PAINT THINNERS
* DRUMMED LIQUID WASTES
  - ABOVE LISTED LIQUIDS
  - POTENTIALLY, DAMAGED HERBICIDE ORANGE DRUMS
* HURRICANE CAMILLE DEBRIS

RECEPTORS (PHYSICAL AND BIOLOGICAL)

* SOIL AND GROUNDWATER AT SITE 4
* SURFACE WATER AND SEDIMENT IN CANAL NO. 1
* SOIL THAT RECEIVES OVERFLOW FROM CANAL NO. 1
* ORGANISMS THAT LIVE OR FEED IN CANAL NO. 1

CONTAMINANT MIGRATION PATHWAYS

* POTENTIALLY CONTAMINATED GROUNDWATER FLOWING TO THE WEST–NORTHWEST
* SEEPS AT THE EDGE OF THE LANDFILL CARRYING POTENTIALLY CONTAMINATED FLUIDS INTO CANAL NO. 1
* SURFACE WATER AND SEDIMENT IN CANAL NO. 1 FLOWING NORTH, EXITING THE BASE AT OUTFALL 1 NORTH

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3.3 EXPOSURE ROUTES/PATHWAYS

Based on the potential contaminant sources and contaminant migration pathways, the following exposure routes and pathways will be evaluated in the risk assessment for Site 4.

Soil

Exposure to contaminated soil at Site 4 under current land use is expected to be limited to surface soil. Under future land use, exposure to chemicals in subsurface soil could occur if the soil were to be uncovered (e.g., during excavation/erosion). In this scenario, it could be assumed that subsurface soil could be brought to the surface and mixed with surface soil. Potential receptors would be assumed to be exposed to the surface/subsurface soil mixture. A receptor may be exposed to soil by inadvertent ingestion of a small amount of soil, by dermal absorption of contaminants from the soil, or by inhalation of vapors or particulates emitted from soil.

Groundwater

Direct exposure to Site 4 groundwater is not expected to occur under current and/or future land usage. Currently available information indicates that no domestic groundwater wells have been installed at or immediately downgradient of Site 4. Therefore, the groundwater is not used as a local source of drinking water. However, to aid in risk management decisions, two conservative scenarios for exposure to groundwater will be evaluated:

- Dermal contact with groundwater should be evaluated for construction workers to account for the possibility that workers may contact groundwater during future excavation activities.

- Current off-site residents and hypothetical future on-site residents could be assumed to use local groundwater as a source of domestic water.

Surface Water/Sediment

Exposure to contaminated surface water and sediment in the drainage ditches adjacent to the landfill could occur under current and future land uses. In this scenario, potential receptors are assumed to come into direct contact with surface water and sediment while wading. Individuals may be exposed primarily via dermal contact and incidental ingestion.

Air

This exposure pathway is based on the assumption that a receptor inhales air containing suspended particulates and/or volatile organic vapors originating from soil. Exposure to fugitive dust and vapors would be an applicable exposure pathway mainly if subsurface soil at the site were to be excavated.

3.4 POTENTIAL RECEPTORS

NCBC Gulfport is an active facility and will remain active for the foreseeable future. Site 4 is currently used as a driving range for Pine Bayou Golf Course and is expected to be used for this purpose in the future. Access to the site is not restricted and children are known to frequently play on the site. Based on current and potential future land use, the following potential receptors may be exposed to contaminated environmental media within the study area:

- Construction//Excavation Workers – Receptors under future land use. No construction activities are currently planned for the study area. Construction workers are considered for future land use only and are assumed to be exposed to subsurface soil and sediment (by ingestion and dermal contact), to groundwater (by dermal contact), and to surface water (by dermal contact).

- Site Commercial/Industrial Workers – Receptors under current and future land use. This includes adult military or civilian personnel working inside facilities located at Site 4 For Example, the Clubhouse for the golf course is less than 200 feet from the landfill, therefore, maintenance workers are assumed to be exposed to surface soil, subsurface soil, and sediment (by ingestion and dermal contact), and to surface water (by dermal contact).

- On-Site Workers – Receptors under current and future land use. This receptor scenario includes adult military or civilian personnel assigned to routine daily maintenance tasks of the golf course and base security. This receptor is assumed to be exposed to surface soil, subsurface soil, and sediment (by ingestion and dermal contact), and to surface water (by dermal contact).

- Recreational Users/Trespassers (Adolescent and Adult) – Receptors under current and future land use. This receptor is assumed to be exposed to surface soil, subsurface soil, and sediment (by ingestion and dermal contact), and to surface water (by dermal contact).

- On-Site Residents (Child and Adult) – Receptors under future land use. Although this scenario is highly unlikely, a future residential scenario is typically evaluated in a risk assessment for decision making purposes. It is assumed that a hypothetical resident may be exposed to surface soil, subsurface soil, and sediment (by ingestion and dermal contact), to groundwater (by ingestion, dermal contact, and inhalation of volatiles), and to surface water (by dermal contact).

- Off-Site Residents (Child and Adult) – Receptors under current and future land use. Because of the close proximity of residential housing to the site, off-site residents are considered to be plausible receptors under current and future land use. The off-site residents are assumed to be exposed in the manner as on-site residents.

3.5 PRELIMINARY RESPONSE OBJECTIVES AND REMEDIAL ACTION ALTERNATIVES

The preliminary response objectives and remedial action alternatives were identified based on the results of previous investigations and were developed to ensure that the data collection during this RI are sufficient to support the screening and detailed analysis of alternatives during the FS.

Based on the conceptual model for Site 4 (Figure 3-1), the primary affected media are groundwater/seeps, subsurface soil, surface water and sediment as evaluated against Tier 1 Unrestricted screening values and (USEPA) MCL's – the chemical specific (ARARs). The remedial action alternatives considered for the impacted media are provided in the following table.

Table 3-1
Remedial Action Objectives and Alternatives
NCBC Gulfport
Gulfport, Mississippi

Media	Remedial Action Objectives	Remedial Action Alternatives
Groundwater Seeps, and Soil	Prevent ingestion or direct contact with material having excess cancer risk of 10^{-6} via source control or removal.	Institutional controls Natural attenuation (passive) Natural attenuation (active) Containment/capping Collection/treatment
Surface Water	Prevent ingestion or direct contact with surface water having excess cancer risk of 10^{-6}. Restore surface water to ambient quality.	Monitoring Runoff interception (SRTs) Discharge treatment
Sediment	Prevent direct contact with sediment having excess cancer risk of 10^{-6}.	Institutional controls Monitoring Runoff interception (SRTs) Excavation

Air	Prevent inhalation of carcinogens in excess of 10^{-6}.	Institutional controls Containment/capping

The data collection and evaluation necessary to evaluate these alternatives are presented in the Sections 4, 5, 6, and 7. A human health risk assessment and a screening level ecological risk assessment will be performed to complete the RI and to establish goals for remedial actions. The technical evaluation for both the human health risk assessment and screening level ecological risk assessment are presented in Section 8.

4.0 WORK PLAN RATIONALE

The following sections will discuss the objectives of the RI and the approach that will be taken to evaluate the remedial objectives.

4.1 DATA QUALITY OBJECTIVES

The Data Quality Objectives (DQOs) for an RI are project specific and are based on the intended use of the data in the decision process (USEPA (EISOPQAM) 1997). DQO selection is the main factor in identifying:

- The types of samples are to be collected
- The sample collection locations
- The types of equipment to be used
- The analytical requirements

The DQOs for Site 4 are presented in Section 4.0 of the Quality Assurance Project Plan (QAPP) (Appendix B) of this Work Plan.

4.2 WORK PLAN APPROACH

The goal of the RI fieldwork is to fill data gaps identified from the previous investigation reports in order to fully define the nature and extent of contamination at Site 4 and to support the baseline risk assessment. A geophysical survey will be conducted to further investigate electromagnetic (EM) anomalies identified during previous investigations. One or more of these anomalies might represent source areas for contaminants. Additional DPT sample locations will be based on the results of this second geophysical survey. The DPT sample locations will be placed around the suspect geophysical anomalies with the highest potential for representing the buried drums. The results from the DPT sampling will then be used to select locations for groundwater monitoring wells. Analyses for suspected contaminants as well as analyses specific to the evaluation of natural attenuation (NA) processes will be collected to determine if either passive or active NA is a viable option for source control or removal. Hydrological data and geotechnical samples will be collected during the RI to support the evaluation of the remedial action alternatives during the FS.

5.0 FIELD INVESTIGATION

The following sections describe the proposed field investigation for the RI at Site 4.

5.1 MOBILIZATION

Field mobilization activities will take place over a 4-day period and will include travel and onsite preparatory activities. These activities will include the marking of sample locations; the receiving, storage and testing of field equipment; initiation of the field data management system (computer database and filing system); and the marking of the primary magnetic anomalies at Site 4.

5.2 FIELD DOCUMENTATION

Field documentation for the RI will include field logbooks, field log forms, location (ID) and sample ID nomenclature, and sample labels.

5.2.1 Field Logbooks

Dedicated field logbooks will be used to record pertinent field activities. (TtNUS. (SOP) QAPP, Appendix C). The project manager's name, the (FOL's) name, the project name and location, and the project number will be recorded on the inside of the front cover of all logbooks. Entries will be recorded with waterproof, non-erasable ink. Each page of the logbook will be numbered and dated. All logbook entries must be legible and contain accurate and complete information about an individual's project activities. At the end of all entries for a particular day, or a particular event if appropriate, the investigator will draw a diagonal line across the page below the last entry and initial indicating the conclusion of entries. All entries will be objective, factual and free of personal feelings or inappropriate language. Corrections should be made by drawing a single line through the error and entering the correct data. All corrections will be initialed and dated.

5.2.2 Location ID and Sample ID Nomenclatures

The nomenclature formats are referenced in the TtNUS, SOP, QAPP, Appendix C.

5.3 UTILITY CLEARANCE

Base personnel will conduct utility clearance at all required locations. (TtNUS, SOP QAPP, Appendix C). Existing records will be reviewed for the intrusive sample locations and each sample location will be cleared with magnetic location devices. Once cleared, each location will be clearly marked (i.e. wooden stake, pin flag, etc) indicating that the location has been cleared for underground utilities. The FOL will accompany the Base utility clearance personnel to the Site to review any restrictions to drilling and monitoring well installation activities.

5.4 GEOPHYSICAL SURVEY

A geophysical survey will be conducted at Site 4 with a focus on the area adjacent to the known vinyl chloride plume to locate buried waste that may indicate a source area or hot spots. (See Figure 3-1) (TtNUS, SOP QAPP, Appendix C). These areas would be considered for excavation should eventual source removal be considered. An EM-61 time-domain metal detector survey will be performed over a 2-acre area with 10-foot grid nodes. A magnetometer survey will be preformed over a 2-acre area with 20-foot grid nodes.

5.5 DIRECT PUSH SAMPLING

Approximately ten DPT borings will be installed at the Site to a total depth of 40 feet bls for the collection of sub-surface soil and groundwater samples. An additional fifteen DPT groundwater samples will be collected from the area of the VOC plume and analyzed for VOCs only to delineate the horizontal and vertical extent of the plume. High resolution dioxin/furan analysis will be collected and analyzed at 20% of the locations. The approximate locations are shown on Figure 5-1 and will be finalized in the field by the FOL based on the results of the geophysical survey, site conditions and the results of the utility clearance. The following sections describe the methods to be used for the collection of these samples.

5.5.1 <u>Subsurface Soil Sampling</u>

A total of 10 sub-surface soil samples will be collected from DPT locations and analyzed for a full suite laboratory analyses listed in Table 5-3. Approximately four sub-surface soil samples will be collected from within the area of the VOC plume. Soil samples collected adjacent to the primary geophysical anomalies at the site. Three of the soil sampling locations will be selected for geotechnical analysis (grain size, moisture content, and Atterberg limits).

Soil samples will be collected continuously at select locations from ground surface to the top of the first significant clay layer. Samples will be collected in acetate sleeves approximately 12 - inches in length. Once at the surface, 3 inches of the sample tube will be cut off and the sample extruded into a plastic bag and sealed. The bag will be labeled with the location ID, the sample depth and the time of collection. This portion of the sample will be set aside and allowed to equilibrate for approximately 20 minutes. A headspace measurement will then be collected by punching a hole with the tip of the (PID) probe into the bag and recording the reading (USEPA EISOPQAM, 1997). The remaining portion of the sample tube will be capped and labeled with the location ID, date and time of collection, and sample depth. The sample tube will then be placed in a plastic bag, sealed and placed in a cooler on ice. The soil sample from the interval exhibiting the highest headspace reading at each location will be transferred to appropriate sample containers and sent to a fixed base laboratory for analysis. The unused samples will be placed in a container with other (IDW) generated at that location. The subsurface soil samples will be analyzed for the full suite of parameters listed in Table 5-3.

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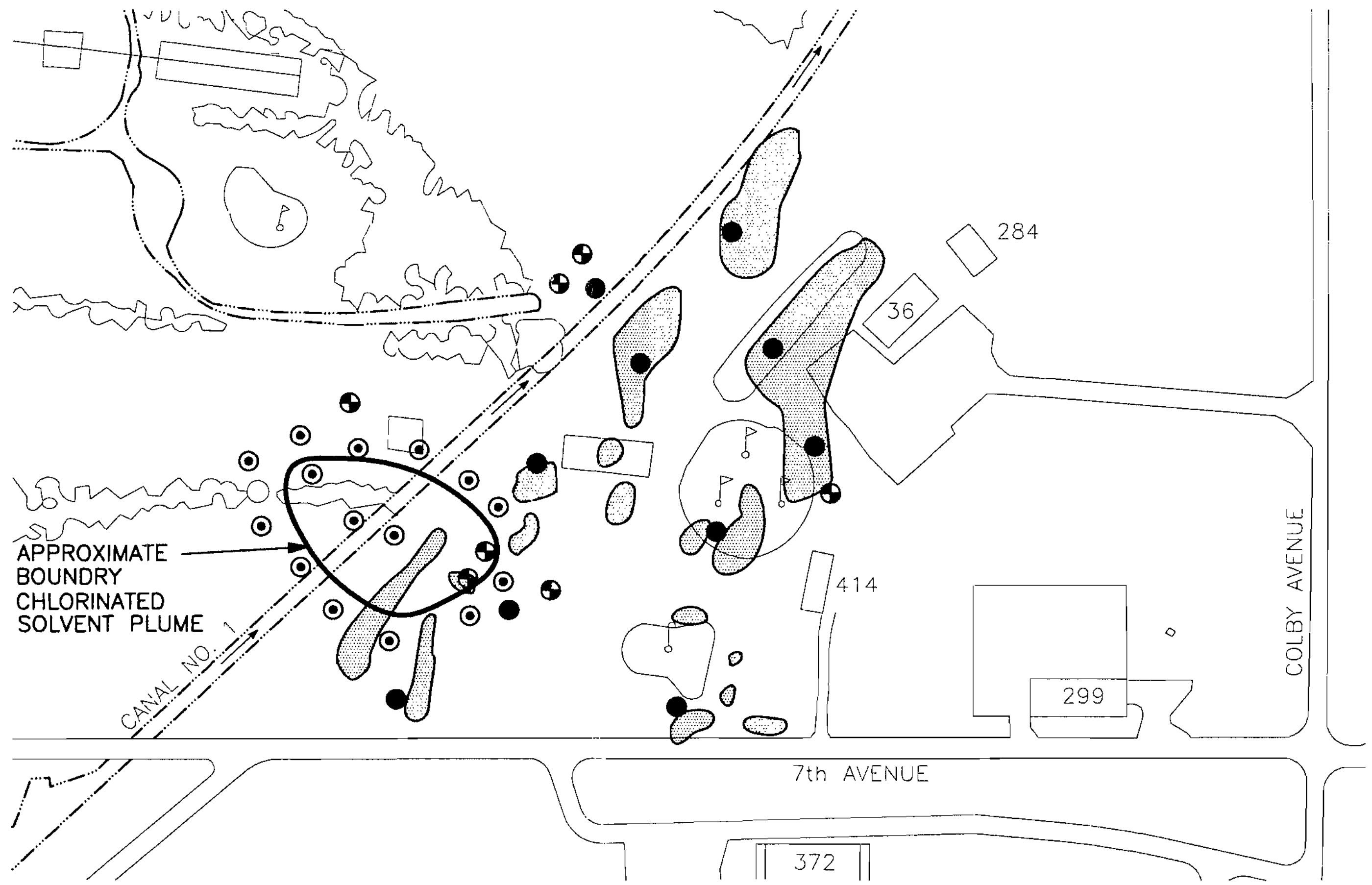

LEGEND:

- MONITORING WELL (EXISTING)
- DPT SAMPLING LOCATION (VOC PLUME)
- DPT SAMPLING LOCATION
- MAGNETIC ANOMALY
- WATERBODY

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DEPARTMENT OF THE NAVY SOUTHERN DIV FACILITIES ENGINEERING COMD

DIRECT PUSH TECHNOLOGY SAMPLING LOCATIONS
SITE 4 REMEDIAL INVESTIGATION WORKPLAN
NAVAL CONSTRUCTION
BATALLION CENTER
GULFPORT, MISSISSIPPI

CONTRACT NO. 9666
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DRAWING NO. FIGURE 5-1
REV. 0

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Table 5-3

DPT SOIL SAMPLE ANALYSES

Soil
TAL Metals
TCL VOCs
TCL SVOCs
TCL Pesticides
TCL PCBs
Dioxin/Furans *
Cyanide
Appendix IX Herbicides
TOC
Geotechnical Parameters
Grain size + moisture
Atterberg limits

***At 20% of the locations**

5.5.2 Groundwater Sampling

Groundwater samples will be collected at each of the 10 DPT soil sampling locations and analyzed for a full suite of analyses including dioxin/furans.

An additional 15 DPT groundwater samples will be collected from the area of the VOC plume and analyzed for VOCs only to delineate the horizontal and vertical extent of the plume. The VOC only samples will be analyzed on a rapid turn around to aid the subsequent placement of permanent ground water monitoring wells. (TtNUS, SOP QAPP, Appendix C).

Following the DPT investigation, groundwater samples will be collected from eight existing and five new groundwater monitoring wells and analyzed for a full suite of analyses including dioxin/furans.

Natural attenuation parameters will be analyzed along with full suite groundwater samples to fully evaluate the viability of either passive or active monitored natural attenuation. The groundwater samples will be analyzed for the full suite of parameters listed in Table 5-4.

Table 5-4

GROUNDWATER SAMPLE ANALYSES

Groundwater
TAL Metals
TCL VOCs
TCL SVOCs
TCL Pesticides
TCL PCBs
Appendix IX Herbicides
Appendix IX Organophosphorous Pesticides
Dioxin/Furans*
Cyanide
Natural Attenuation Parameters
TOC
Anions
Dissolved gasses
Dissolved hydrogen

*At permanent well locations only

5.6 ADDITIONAL MEDIA SAMPLING

Additional media sampling for this field investigation includes collection of surface water, sediment, surface soil, and seep samples at selected locations. (TtNUS, SOP QAPP, Appendix C).

Three co-located surface water/sediment samples will be collected from Canal No. 1, the drainage ditch that bounds the western extent of Site 4, see Figure 5-2. Five additional sediment samples will be collected (two upstream and three downstream of the site). At locations where co-located surface water/sediment samples will be collected, the surface water sample will be collected prior to the collection of the sediment sample. Water quality parameters including pH, specific conductance, temperature and turbidity, will be measured at each surface water sample location (USEPA EISOPQAM, 1997).

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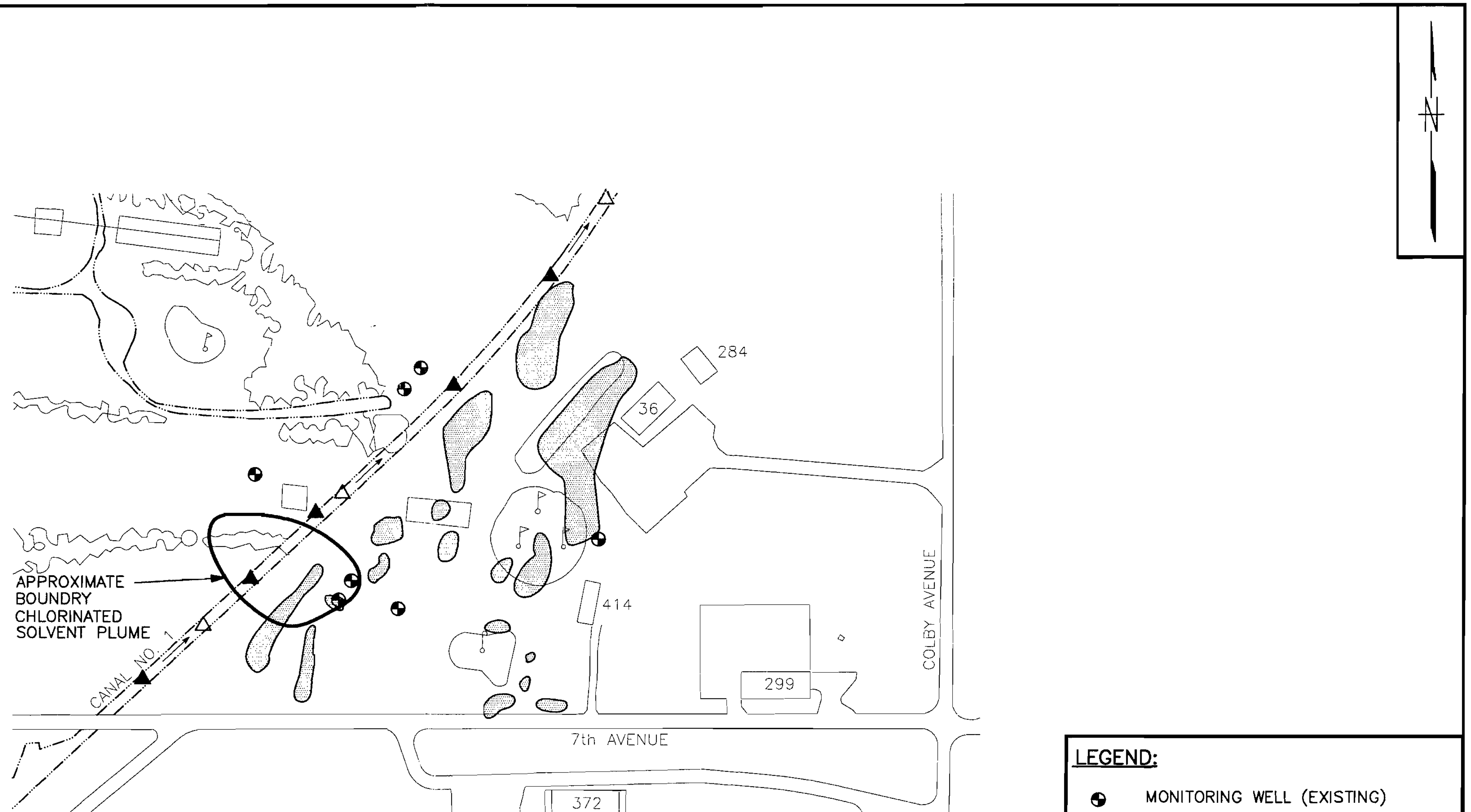

LEGEND:

- MONITORING WELL (EXISTING)
- SURFACE WATER/SEDIMENT SAMPLE
- SEDIMENT SAMPLE
- MAGNETIC ANOMALY
- WATERBODY

0 200 400

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SURFACE WATER/SEDIMENT SAMPLING LOCATIONS
SITE 4 REMEDIAL INVESTIGATION WORKPLAN
NAVAL CONSTRUCTION
BATALLION CENTER
GULFPORT, MISSISSIPPI

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The sample containers will then be properly labeled, sealed in a plastic bag, and packed in a cooler on ice. The surface water samples will be analyzed for the parameters listed in Table 5-5.

Sediment samples will be collected using a clean stainless steel hand auger. Due to the correlation between TOC and the presence of TCDD (HLA, 1997), the sampler will attempt to collect the sample from the area demonstrating the highest apparent organic content. The sample will then be extruded from the hand auger into a glass bowl for mixing. The volatile fraction of the sediment sample will be placed in the sample container immediately after being extruded from the hand auger and prior to mixing. To ensure adequate mixing the material should be stirred in a circular fashion, reversing direction, and occasionally turning the material over. Once thoroughly mixed, the sample will be placed into the appropriate sample containers. The sample containers will then be properly labeled, sealed in a plastic bag, and packed in a cooler on ice. The sediment samples will be analyzed for the parameters listed in Table 5-5.

Two co-located surface soil and seep samples will be collected from locations of opportunity during the investigation.

TABLE 5-5

ADDITIONAL MEDIA ANALYSES

Surface Water	Sediment	Surface Soil	Seep
TAL Metals +CN	TAL Metals	TAL Metals	TAL Metals
TCL VOCs	TCL VOCs	TCL VOCs	TCL VOCs
TCL SVOCs	TCL SVOCs	TCL SVOCs	TCL SVOCs
TCL Pesticides	TCL Pesticides	TCL Pesticides	TCL Pesticides
TCL PCBs	TCL PCBs	TCL PCBs	TCL PCBs
Chlorinated Herbicides (8151)	Chlorinated Herbicides (8151)	Chlorinated Herbicides (8151)	Chlorinated Herbicides (8151)
Dioxins 8290	Dioxins 8290 *	Dioxins 8290	Dioxins 8290

* At 20% of the locations only

5.7 DRILLING AND MONITORING WELL INSTALLATION

Three additional shallow water table monitoring wells and two vertical extent wells will be installed at Site 4. The wells will be installed using the hollow stem auger drilling method. The borings will be a minimum of 6 ½-inches in diameter and will be advanced to a depth of approximately 25 feet BLS for the shallow wells and to 50 feet bls for the vertical extent wells. To prevent collapsed borehole material and running sands from entering the augers, a wooden plug will be placed in the head of the auger during drilling and the wells will be installed through the augers. The wells will be constructed of 2 - inch (ID), schedule 40 (PVC) well materials. The well screen will be 0.010 slot, and will be 10 feet in length. A minimum of 6 inches of filter pack material will be placed below the well screen to provide a firm footing and to ensure unrestricted flow under the screen. A filter pack of 20-60-grade clean silica sand will be placed around the screen and will be brought to a minimum of 2 feet above the top of the screen. A 2 foot thick bentonite seal will then be placed on top of the filter pack and hydrated with potable water. The seal should consist of 30% solids bentonite pellets (USEPA EISOPQAM, 1997). Care should be taken during placement of the bentonite pellets to ensure that bridging of the pellets inside the augers does not occur. The bentonite seal will then be allowed to hydrate for a minimum of 8 hours. Once the bentonite seal has hydrated, the remaining annulus will be filled with a cement/bentonite grout to within 2 feet of the ground surface. The grout will then be allowed to cure for 24 hours prior to beginning surface completion activities. (TtNUS, SOP QAPP, Appendix C).

Where possible, the wells will be constructed with above ground surface completions. Flush mount completions may be used in areas where above ground completions might conflict with traffic or training activities. For wells completed above ground, the well casing should extend at least 2.5 feet above the ground surface. An outer steel protective casing, 4-inches square by 5 feet long, with a hinged locking cap will be installed. A 3-foot x 3-foot x 6-inch concrete pad will be installed around each well. A minimum of 2 ¼-inch diameter weep holes will be drilled in the protective casing just above the top of the concrete pad. Four steel guard posts 3 to 4 inches in diameter and a minimum of 5 feet in length will be placed at the corners of the pad. The posts will be set at least 2 feet into the ground in a concrete footing and extend at least 3 feet above ground surface. The posts will be filled with concrete for additional strength (Southern Division Monitoring Well Specifications, 1999). The surface casing and guard posts will be painted traffic yellow. A vented, PVC slip on cap will be placed at the top of the well to permit pressure equalization.

Wells requiring a flush mount surface completion will be constructed with a 2x2 foot concrete pad and a bolt down, water tight well vault approximately 6 inches in diameter. A water tight, expandable locking cap will be placed at the top of the well to prevent surface water infiltration.

5.7.1 Monitoring Well Development

The newly installed wells will be developed with a mechanical pump to ensure that the groundwater samples are representative of site conditions. Well development will involve surging and the removal of a minimum of three and a maximum of five well volumes. The well volume (volume of water within the well casing) will be calculated prior to initiating the development. This will be done by determining the ID of the well and by measuring and recording the total depth of the well and the depth to water from the top of the well casing. The water level is then subtracted from the total depth and this length is then multiplied by the appropriate factor from Table 5-6 to obtain the amount of water, in gallons, within the well casing. Water quality parameters will be monitored during development with a reading taken every volume. The parameters to be measured will include pH, specific conductance, temperature and turbidity. Development will continue until the water in the well is free of visible sediment and the parameters have stabilized as described in Section 5.6.3 of the USEPA EISOPQAM (EPA, 1997). Development water will be containerized in 55-gallon drums for later disposal. The drums will be appropriately labeled as to the contents and the source. (TtNUS, SOP QAPP, Appendix C).

TABLE 5-6

WELL CASING VOLUME VS. DIAMETER

Casing Inside Diameter (inches)	Gallons/Foot of Water
1	0.041
2	0.163
4	0.653

5.7.2 Groundwater Sampling

A total of 13 (five new and eight existing) monitoring wells will be sampled for this field investigation (Figure 5-3). Prior to sampling all wells will be purged of approximately three to five well volumes. The well volume (volume of water within the well casing) will be calculated prior to initiating the purge. Additionally, water quality parameters will be measured at the initiation of purging and at a minimum after the removal of each well volume. More frequent measurements may be necessary to confirm stabilization. Purging will continue until at least three well volumes have been removed and the water quality parameters (pH, specific conductance, and temperature) have stabilized and turbidity has either stabilized or is below 10 Nephelometric Turbidity Units (NTUs). If after removing five well volumes from the well the parameters have still not stabilized, it will be the discretion of the FOL whether to sample or to continue purging. (TtNUS, SOP QAPP, Appendix C).

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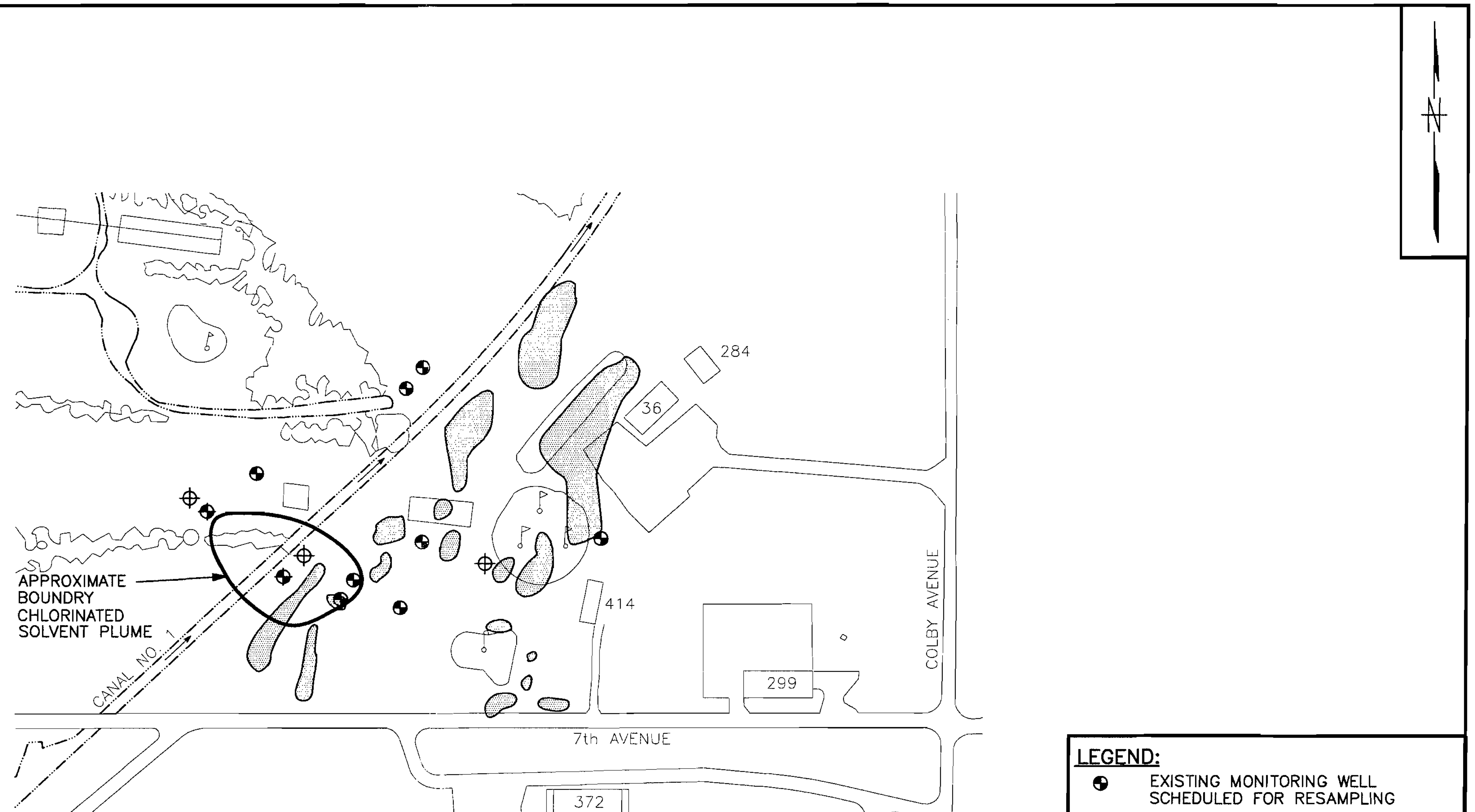

LEGEND:

- EXISTING MONITORING WELL SCHEDULED FOR RESAMPLING
- NEW SHALLOW MONITORING WELL LOCATION
- NEW VERTICAL EXTENT MONITORING WELL
- MAGNETIC ANOMALY
- WATERBODY

0 200 400
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NEW MONITORING WELL AND GROUNDWATER SAMPLING LOCATIONS
SITE 4 REMEDIAL INVESTIGATION WORKPLAN
NAVAL CONSTRUCTION BATALLION CENTER
GULFPORT, MISSISSIPPI

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Sampling should be conducted as soon after the purging process is completed provided that there is a sufficient volume of water in the well. Samples will be collected using disposable Teflon bailers. New plastic sheeting will be placed around the well to provide a clean work area. Clean nylon rope will be attached to the bailer and the bailer will be gently lowered into the water column until just submerged. Once filled, the bailer will be carefully removed and the contents emptied into the appropriate sample containers. The sample containers will then be labeled, sealed in a plastic bag, and placed in a cooler on ice. The volatile fraction of the sample should be collected first to minimize contaminant losses due to volatilization. Sample containers for all samples requiring preservation will be pre-preserved by the lab. The groundwater samples will be analyzed for the parameters listed in Table 5-4.

5.8 DECONTAMINATION PROCEDURES

All sampling and downhole drilling equipment must be cleaned and decontaminated prior to use and after each subsequent use. A decon pad will be constructed in an area provided by the base. The area should be relatively level and free of known surface contamination. The pad will be bermed and lined with plastic so as not to leak. Racks used to hold equipment during cleaning should be high enough to prevent the equipment from being splashed. After cleaning, equipment will only be handled by personnel wearing clean gloves to prevent recontamination. The following is a description of the materials to be used in the decon process and the decon procedures to be used for the specific types of equipment (USEPA EISOPQAM, 1997). (TtNUS, SOP QAPP, Appendix C).

<u>Specifications for Cleaning Materials</u>:

- Soap - will be a standard phosphate-free laboratory detergent (e.g. Liquinox®).
- Solvent - will be pesticide grade isoproponal.
- Tap Water - may be used from any municipal water system.
- Analyte Free Water - deionized (DI) water should contain no detectable heavy metals or other inorganic compounds.

<u>Procedures</u>:

<u>Sampling equipment</u>:

1. Clean with tap water and soap, being sure to remove particulate matter and surface films, using a brush if necessary.
2. Rinse thoroughly with tap water.

3. Rinse thoroughly with DI water.
4. Rinse thoroughly with solvent. PVC or plastic items should not be solvent rinsed.
5. Rinse thoroughly with DI water.
6. Remove from the decon area and cover with clean plastic. If equipment is to be stored overnight it will be wrapped in aluminum foil and covered with clean unused plastic.

<u>Water Level Meter</u>:

1. Wash with soap and tap water.
2. Rinse with tap water.
3. Rinse with DI water.

<u>Redi-Flo2â Pump</u>:

CAUTION - the pump should be unplugged prior to cleaning.

1. The exterior of the pump, the electrical cord and hose will be scrubbed using a brush, soap and tap water. Do not wet the electrical plug.
2. Rinse with tap water.
3. Rinse with DI water.
4. Place the equipment in a clean plastic bag.

The pump check valve will be cleaned as follows:

1. Disassemble the check valve assembly.
2. Scrub all components with a brush, soap and tap water.
3. Rinse with DI water.
4. Reassemble.

<u>Downhole Drilling Equipment</u>:

1. Steam clean with soap and high-pressure hot water. If necessary, a brush will be used to remove particulate matter not removed by steam cleaning.
2. Rinse thoroughly with tap water.
3. Remove from the decon pad and cover with clean, unused plastic. If the equipment will be stored overnight the plastic will be secured to ensure that it stays in place.

5.9 AQUIFER TESTING

Slug tests will be conducted at three wells to estimate the characteristics of the surficial aquifer. The slug tests will be performed by adding or removing a slug of known volume to the well, causing a change in the water level. The recovery of the water level to static will then be measured at frequent intervals with an electronic pressure transducer and electronic data logger. The slug test recovery data will be analyzed using the Bouwer-Rice method to estimate the transmissivity and hydraulic conductivity of the aquifer.

One constant yield pumping test will be performed in a deeper vertical extent well to support the determination of hydraulic conductivity, transmissivity, and coefficient of storage/specific yield of the unconfined aquifer. (TtNUS, SOP QAPP, Appendix C).

5.10 WATER LEVEL MEASUREMENTS

Two rounds of water level measurements will be collected from 13 monitoring wells at and around Site 4. These data will be used to determine the hydraulic gradient of the surficial aquifer and will be presented as the potentiometric surface map in the RI report. All measurements will be collected with an electronic water level meter and will be referenced to the surveyed measuring point identified at the top of the well casing. Measurements will be made and recorded to the nearest 0.01 foot. (TtNUS, SOP QAPP, Appendix C).

5.11 LAND SURVEYING

The horizontal location and the top of casing elevation of each permanent monitoring well and piezometer will be surveyed by a TtNUS subcontracted, state licensed land surveyor. The horizontal location and ground surface elevation of all sample locations will also be surveyed. All locations will be reference to site features such as building corners, roads, etc.

5.12 IDW MANAGEMENT

TtNUS estimates that approximately 20 drums of investigation derived waste IDW will be generated during the field investigation. IDW management includes labeling, record keeping, and staging of materials. All drums will be labeled with the following information:

- Source of material (i.e. boring/well ID, decon pad, etc.)
- Matrix (i.e. soil, groundwater, decon water, etc.)

- Date generated (mmddyy)
- Contractor name and contact phone number

(PPE) will be double bagged and placed in facility dumpsters. TtNUS will be responsible for disposal costs and the Base (NCBC Gulfport), will be responsible for signing manifests associated with the disposal of all IDW. (TtNUS, SOP QAPP, Appendix C).

5.13 DEMOBILIZATION

Demobilization will occur at the conclusion of all other field activities related to this investigation. Activities that will occur during this phase include the installation of 17 well tags on both new and existing monitoring wells, the return of all rental field equipment, the verification of proper IDW documentation and staging by the FOL, and the securing of the site.

6.0 LABORATORY ANALYSES

This section identifies the analytical program for this field investigation. The number of samples to be collected per sampling method per matrix is listed in Table 6-1. The analyses and analytical methods to be used and the total number of samples per analysis, including (QA/QC) samples are listed in Table 6-2.

TABLE 6-1

NUMBERS OF SAMPLES

Method	Media	No. of Samples	QA/QC			
			Duplicates	Rinsates	(MS/MSD)	Trip
DPT:						
	Subsurface Soil	10	1	1	1	0
	Groundwater	25	3	3	2	4
Monitoring Wells:						
	Groundwater	13	2	2	1	2
Additional Media:						
	Surface Water	3	1	1	1	1
	Sediment	8	1	1	1	1
	Surface Soil	2	1	1	1	0
	Seep	2	1	1	1	1

Note: 10 DPT groundwater samples will be collected for full suite analysis and 15 DPT groundwater samples will be analyzed for VOCs only.

TABLE 6-2

ANALYTICAL PARAMETERS AND METHODS

Parameter	Method (aqueous/soil)	No. Soil	No. Aqueous
TAL Metals +CN	SW-846 6061B/7000A	27	47
TCL VOCs	SW-846 8260B	27	71
TCL SVOCs	SW-846 8270C	27	47
TCL Pesticides	SW-846 8081A	27	47
TCL PCBs	SW-846 8082	27	47
Chlorinated Herbicides	SW-846 8151B	27	47
Organophosphorous Pesticides		0	36
Dioxin/Furans	SW-846 8290	13	16
Anions (nitrite, nitrate, sulfate, sulfide, chloride)	EPA 300.0	0	28
Dissolved Gasses (methane, ethane, ethane)	SW-846 3810 or RSK SOP 147 and 175	0	28
TOC	SW-846 9060	26	28
Dissolved hydrogen	Bubble strip method	0	28
Grain size and moisture content	ASTM D 421/422	3	0
Atterberg Limits	ASTM D 4318	3	0

Note: Soil samples include surface soil, subsurface soil, sediment samples, and associated field duplicates and MS/MSDs. Aqueous samples include groundwater, surface water, seep, associated field duplicates and MS/MSDs, and rinsates.

7.0 DATA MANAGEMENT

This section will discuss the methods to be used to manage the data generated during this field investigation. This includes the tracking of data in the field and subsequent data validation. A Data Management Plan (DMP) is included in Appendix A and outlines the project-specific Information Management System (IMS) that will be used to manage the environmental information pertaining to the Base.

7.1 ONSITE DATA MANAGEMENT

Onsite data management involves the day-to-day recording of all sampling and field activities in the field. A project database will be initiated in the field to promote the proper collection and storage of field data and documentation of field activities. The following data will be entered into the project database in the field: (TtNUS, SOP QAPP, Appendix C).

- Sample information (i.e. identification, sample matrix, sample depth, collection time, analyses, etc.)
- Location information
- Chain of custody information
- Shipping data
- Field descriptions
- Photographic logs

The FOL and/or sample coordinator will be responsible for entering the data into the database in the field.

7.2 DATA VALIDATION

All (field natural attenuation) data will be subjected to full validation. The data will be assessed using precision, accuracy, representativeness, completeness and comparability (PARCC) parameters using the National Validation Functional Guidelines for Organic Data Review (June 1991), the Laboratory Data Validation Functional Guidelines for Evaluation of Inorganic Analysis (June 1988), and TtNUS SOPs. (TtNUS SOP QAPP, Appendix C).

8.0 RISK ASSESSMENT

A baseline human health/ecological risk assessment will be conducted as part of this RI. Baseline risk assessments evaluate the potential threat to human health and the environment in the absence of any remedial action, providing the basis for determining whether remedial action is necessary and the justification for performing remedial actions. The baseline risk assessment will also be used to support a finding of imminent and substantial endangerment if such a finding is required as part of an enforcement action. Detail guidance on evaluation of potential human health impacts as part of this baseline assessment is provided in the *Superfund Public Health Evaluation Manual (SPHEM)* (U.S. EPA, October 1986). Guidance for evaluating ecological risks is currently under development within (OSWER). (TtNUS, SOP QAPP, Appendix C).

8.1 OBJECTIVES OF THE BASELINE RISK ASSESSMENT

In general, the objectives of a baseline risk assessment may be attained by identifying and characterizing the following:

- Toxicity and levels of hazardous substances present in relevant media (e.g., air, ground water, soil, surface water, sediment, and biota)
- Environmental fate and transport mechanisms within specific environmental medial such as physical, chemical, and biological degradation processes and hydrogeological conditions
- Potential human and environmental receptors
- Potential exposure routes and extent of actual or expected exposure
- Extent of expected impact or threat; and the likelihood of such impact or threat occurring (i.e., risk characterization)
- Level(s) of uncertainty associated with the above items

The level of effort required to conduct a baseline risk assessment depends largely on the complexity of the site. The goal is to gather sufficient information to adequately and accurately characterize the potential risk from a site, while at the same time conduct this assessment as efficiently as possible. Use of the conceptual site model developed and refined previously will help focus investigation efforts and, therefore, streamline this effort. Factors that may affect the level of effort required include:

- The number, concentration, and types of chemicals present
- Areal extent of contamination

- The quality and quantity of available monitoring data
- The number and complexity of exposure pathways (including the complexity of release sources and transport media)
- The required precision of sample analyses, which in turn depends on site conditions such as the extent of contaminant migration and the proximity, characteristics, and size of potentially exposed population(s)
- The availability of appropriate standards and/or toxicity data

8.2 COMPONENTS OF THE BASELINE RISK ASSESSMENT

The risk assessment process can be divided into four components:

- Contaminant identification
- Exposure assessment
- Toxicity assessment
- Risk characterization

A brief overview of each component follows.

Contaminant Identification. The objective of contaminant identification is to screen the information available on hazardous substances or wastes present at the site and to identify contaminants of concern to focus subsequent efforts in the risk assessment process. Contaminants of concern may be selected because of their intrinsic toxicological properties, because they are present in large quantities or because they are presently in or potentially may move into critical exposure pathways (e.g., drinking water supply).

It may be useful for some sites to select “indicator chemicals” as part of this process. Indicator chemicals are chosen to represent the most toxic, persistent, and/or mobile substances identified at a site that are likely to significantly contribute to the overall risk posed by the site. In some instances, an indicator chemical may be selected for the purpose of representing a “class” of chemicals (e.g., TCE to represent all volatiles). Although the use of indicator chemicals serves to focus and streamline the assessment on those chemicals that are likely to be of greatest concern, a final check will need to be made during remedy selection and the remedial action phase to ensure the waste management strategy implemented addresses risks posed by the range of contaminants found at the site.

Exposure Assessment. The objectives of an exposure assessment are to identify actual or potential exposure pathways, to characterize the potentially exposed populations, and to determine the extent of the exposure. Detailed guidance on conducting exposure assessments is provided in the Superfund Exposure Assessment Manual (U.S. EPA, April 1988), and is briefly discussed below.

Identifying potential exposure pathways helps to conceptualize how contaminants may migrate from a source to an existing or potential point of contact. An exposure pathway may be viewed as consisting of four elements:

1. A source and mechanism of chemical release to the environment;
2. An environmental transport medium (e.g., air, ground water) for the released chemical;
3. A point of potential contact with the contaminated medium (referred to as the exposure point); and
4. An exposure route (e.g., inhalation, ingestion) at the exposure point.

The analysis of the contaminant source and how contaminants may be released involves characterizing the contaminants of concern at the site and determining the quantities and concentrations of contaminants released to environmental media. Figure 3-1 presents a conceptual example identifying actual and potential exposure pathways.

Once the source(s) and release mechanisms have been identified, an analysis of the environmental fate and transport of the contaminants is conducted. This analysis considers the potential environmental transport (e.g., ground-water migration, airborne transport); transformation (e.g., biodegradation, hydrolysis, and photolysis); and transfer mechanisms (e.g., sorption, volatilization) to provide information on the potential magnitude and extent of environmental contamination. Next, the actual or potential exposure points for receptors are identified, focusing on those locations where actual contact with the contaminants of concern will occur or is likely to occur. Last, potential exposure routes that describe the potential uptake mechanism (e.g., ingestion, inhalation, etc.) once a receptor comes into contact with contaminants in a specific environmental medium are identified and described. Environmental media that may need to be considered include air, ground water, surface water, soil and sediment, and food sources. Detailed procedures for estimating and calculating rates of exposure are described in detail in the *Superfund Exposure Assessment Manual.*

After the exposure pathway analysis is completed, the potential for exposure should be assessed. Information on the frequency, mode, and magnitude of exposure(s) are gathered. These data are then assessed to yield a value representing the amount of contaminated media contacted per day. This analysis should include both the identification of current exposures and of exposures occuring in the future if no action is taken at the site. Because the frequency, mode and magnitude of human exposures will vary based on the primary use of the area (e.g., residential, industrial, or recreational), the expected use of the area in the future should be evaluated. The purpose of this analysis is to provide decision-makers with an understanding of both the current risks and potential future risks if no action is taken. Therefore, as part of this evaluation, a reasonable maximum exposure scenario should be developed, which reflects the type(s) and extent of exposures that could occur based on the likely or expected use of the site (or surrounding areas) in the future. The reasonable maximum exposure scenario is presented to the decision-maker so that possible implication of decisions regarding how to best manage uncertainties can be factored into the risk management remedy selection.

The final step in the exposure assessment is to integrate the information and develop a qualitative and/or quantitative estimate of the expected exposure level(s) resulting from the actual or potential release of contaminants from the site.

Toxicity Assessment. Toxicity assessment, as part of the Superfund baseline risk assessment process, considers:

1. the types of adverse health or environmental effects associated with individual and multiple chemical exposures;
2. the relationship between magnitude of exposures and adverse effects; and
3. related uncertainties such as the weight of evidence for a chemical's potential carcinogenicity in humans.

Detailed guidance for conducting toxicity assessments is provided in the SPHEM.

Typically, the Superfund risk assessment process relies heavily on existing toxicity information and does not involve the development of new data on toxicity or dose-response relationships. Available information on many chemicals is already evaluated and summarized by various EPA program offices or cross-Agency work groups in health and environmental effects assessment documents. These documents or profiles will generally provide sufficient toxicity and dose-response information to allow both qualitative and quantitative estimates of risks associated with many chemicals found at Superfund sites. These documents often estimate carcinogen exposures associated with specific lifetime cancer risk (e.g., risk-specific doses (RSDs), and systemic toxicant exposures that are not likely to present appreciable risk of significant adverse effects to human populations over a lifetime (e.g., Reference Doses or (RfDs).

Risk Characterization. In the final component of the risk assessment process, a characterization of the potential risks of adverse health or environmental effects for each of the exposure scenarios derived in the exposure assessment, is developed and summarized. Estimates of risks are obtained by integrating information developed during the exposure and toxicity assessments to characterize the potential or actual risk, including carcinogenic risks, noncarcinogenic risks, and environmental risks. The final analysis should include a summary of the risks associated with a site including each projected exposure route for contaminants of concern and the distribution of risk across various sectors of the population. In addition, such factors as the weight-of-evidence associated with toxicity information, and any uncertainties associated with exposure assumptions should be discussed.

Characterization of the environmental risks involves identifying the potential exposures to the surrounding ecological receptors and evaluating the potential effects associated with such exposure(s). Important factors to consider include disruptive effects to populations (both plant and animal) and the extent of perturbations to the ecological community.

The results of the baseline risk assessment may indicate the site poses little or no threat to human health or the environment. In such situations, the FS should be either scaled down as appropriate to site and its potential hazard, or eliminated altogether. The results of the RI and the baseline risk assessment would serve as the primary means of documenting a no-action decision. If it is decided the scope of the FS will be less than what is presented in this guidance or eliminated altogether, the lead agency should document this decision and receive the concurrence of the support agency.

8.3 SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT

The screening level Ecological Risk Assessment (ERA) follows the USEPA Guidance *"Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments" (USEPA, 1997).* The guidance requires that a screening level ERA be completed to determine whether the site poses no (or negligible) risk, or whether further evaluation is required. Although the screening level ERA is consistent with the referenced guidance document; it is also consistent with the methodologies and current guidance materials from USEPA, including:

- Risk Assessment Guidance for Superfund: Environmental Evaluation Manual (USEPA, 1989c)
- Ecological Assessment at Hazardous Waste Sites: A Field and Laboratory Reference (USEPA, 1989d)
- Framework for Ecological Risk Assessment (USEPA, 1992d)

- Ecological Risk Assessment Guidance for Superfund: Process for Designing And Conducting Ecological Risk Assessment (USEPA, 1997b)

- Supplemental Guidance to (RAGS) Region 4 Bulletins on Ecological Risk Assessment (USEPA, 1995b) and

- Guidelines for Ecological Risk Assessment (USEPA, 1998a).

This assessment will include a hazard assessment, exposure assessment, toxicity assessment, risk characterization, and the screening level ERA summary and recommendations.

9.0 COSTS AND KEY ASSUMPTIONS

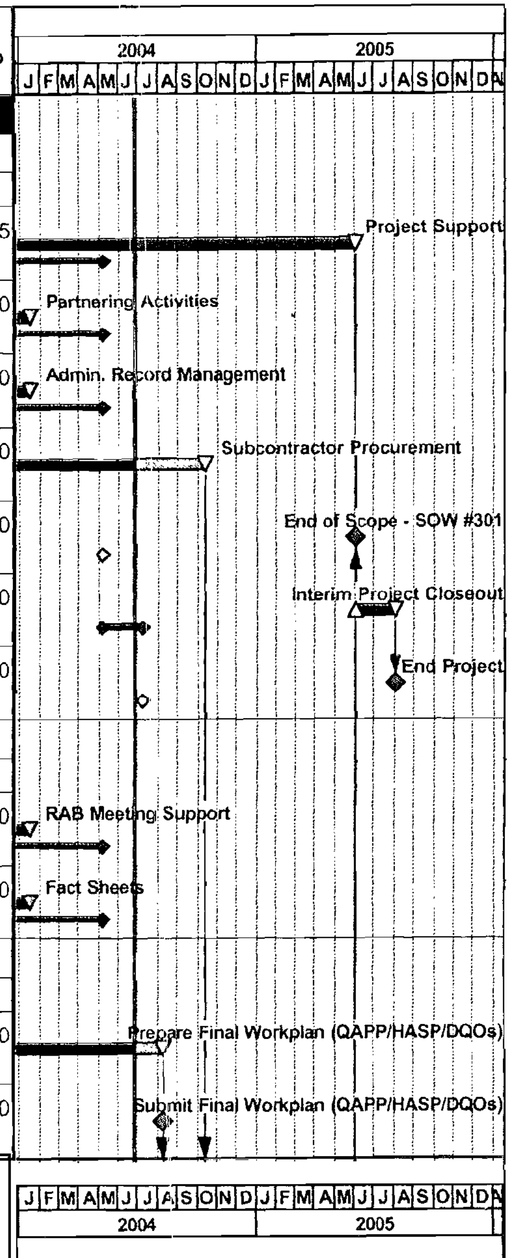
Costs and key assumptions developed for the scope of this RI are contained in Section 4.0 of this report and in the Plan of Action (dated 10 Feb 03).

Field operations that deviate from this Work Plan, and do not have an impact on project costs, will be documented via the Field Change Request Forms available at the site. These deviations will not take place until the Project Manager has signed off and the (RPM) has been notified of the proposed changes.

Any changes or deviations that result in a change of scope can not be acted upon until the Project Manager has been notified and has received an approval letter from the RPM through the Project Management Office (PMO).

10.0 SCHEDULE

Activity ID	Activity description	Cal ID	Hours to Complete	Cost to Complete	Early Start	Early Finish	May TFMR Finish	Orig Dur	Rem Dur	% Comp
CTO 283 NCBC GULFPORT - RI @ SITE 4										
PROJECT MANAGEMENT										
MOD 01										
PQ0010105	Project Support	1	57.00	7,674.38	07MAR03A	03JUN05	***22APR05***	816*	339*	35
PQ0010110	Partnering Activities	1	0.00	0.00	07MAR03A	16JAN04A	***16JAN04A***	659	0	100
PQ0010115	Admin. Record Management	1	0.00	0.00	07MAR03A	16JAN04A	***16JAN04A***	659	0	100
PQ0010130	Subcontractor Procurement	1	22.00	518.76	16OCT03A	14OCT04	***07SEP04***	363*	108*	0
PQ0010225	End of Scope - SOW #301	1	0.00	0.00		03JUN05	***22APR05***	0	0	0
PQ0010230	Interim Project Closeout	1	0.00	0.00	04JUN05	03AUG05	***21JUN05***	60	60	0
PQ0010233	End Project	1	0.00	0.00		03AUG05	***21JUN05***	0	0	0
COMMUNITY RELATIONS										
MOD 01										
PQ0020100	RAB Meeting Support	1	0.00	0.00	07MAR03A	16JAN04A	***16JAN04A***	659	0	100
PQ0020200	Fact Sheets	1	0.00	0.00	07MAR03A	16JAN04A	***16JAN04A***	659	0	100
WORK PLANS										
MOD 01										
PQ0040140	Prepare Final Workplan (QAPP/HASP/DQOs)	2	35.00	767.53	16OCT03A	09AUG04	***02JUL04***	20	30	20
PQ0040142	Submit Final Workplan (QAPP/HASP/DQOs)	2	0.00	0.00		09AUG04	***02JUL04***	0	0	0



WORK PLANS DONE?.....YOU GET AUTORIZATION TO DO FIELD WORK?

Start Date	31MAR95
Finish Date	03AUG05
Data Date	28JUN04
Run Date	08JUN04 07:48

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Early Bar
Target Bar
Progress Bar
Critical Activity

NAVA - CX83 Sheet 1 of 4

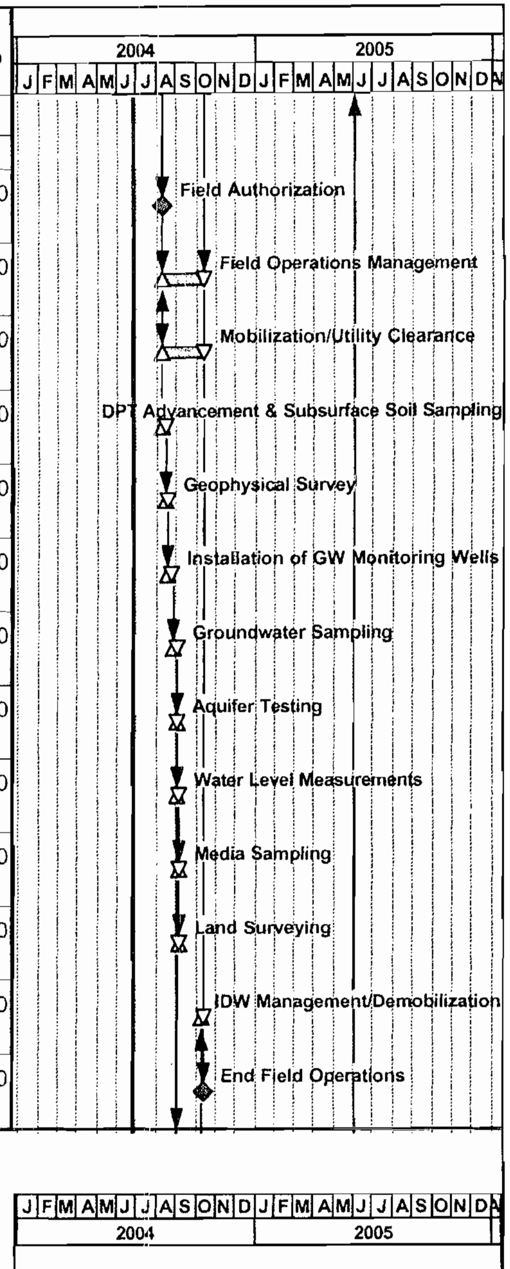
NAVY CLEAN III
T.O.M. SCHEDULE
PERIOD ENDING: 6/27/2004

TetraTech NUS

Layout:
LT-11: TOM Schedule Turnarounds (TASK)

Filter:
FL-22: TOM Schedules (STD TASK Layout)

Activity ID	Activity description	Cal ID	Hours to Complete	Cost to Complete	Early Start	Early Finish	May TFMR Finish	Orig Dur	Rem Dur	% Comp
FIELD INVESTIGATION										
MOD 01										
PQ0050100	Field Authorization	1	0.00	0.00	10AUG04			0	0	0
PQ0050105	Field Operations Management	1	837.00	48,687.21	10AUG04	14OCT04	***07SEP04***	66*	66*	0
PQ0050110	Mobilization/Utility Clearance	1	0.00	0.00	10AUG04	14OCT04	***07SEP04***	66*	66*	0
PQ0050120	DPT Advancement & Subsurface Soil Sampling	1	0.00	12,703.50	10AUG04	14AUG04	***08JUL04***	5	5	0
PQ0050130	Geophysical Survey	1	0.00	0.00	15AUG04	19AUG04	***13JUL04***	5	5	0
PQ0050140	Installation of GW Monitoring Wells	1	0.00	10,175.00	20AUG04	24AUG04	***18JUL04***	5	5	0
PQ0050150	Groundwater Sampling	1	0.00	0.00	28AUG04	01SEP04	***26JUL04***	5	5	0
PQ0050160	Aquifer Testing	1	0.00	0.00	02SEP04	03SEP04	***28JUL04***	2	2	0
PQ0050165	Water Level Measurements	1	0.00	0.00	04SEP04	04SEP04	***29JUL04***	1	1	0
PQ0050180	Media Sampling	1	0.00	0.00	05SEP04	05SEP04	***30JUL04***	1	1	0
PQ0050190	Land Surveying	1	0.00	2,900.00	06SEP04	06SEP04	***31JUL04***	1	1	0
PQ0050200	IDW Management/Demobilization	1	0.00	1,905.00	12OCT04	14OCT04	***07SEP04***	3	3	0
PQ0050222	End Field Operations	1	0.00	0.00		14OCT04	***07SEP04***	0	0	0



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Finish Date	03AUG05
Data Date	28JUN04
Run Date	08JUN04 07:48

Early Bar
Target Bar
Progress Bar
Critical Activity

NAVA - CX83 Sheet 2 of 4

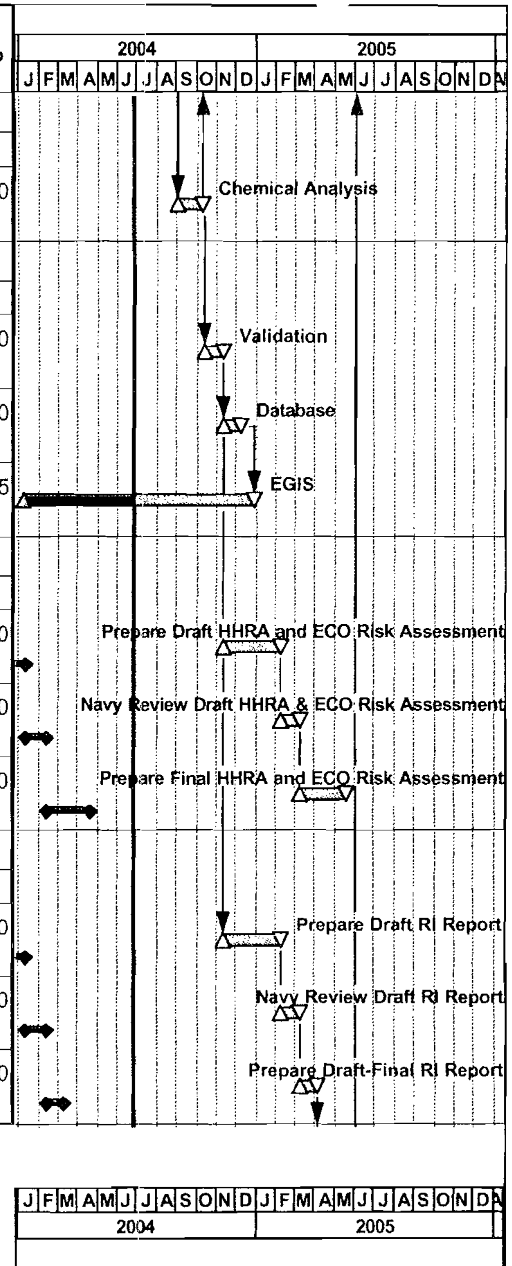
NAVY CLEAN III
T.O.M. SCHEDULE
PERIOD EN 3: 6/27/2004

TetraTech NUS

Layout:
LT-11: TOM Schedule Turnarounds (TASK)

Filter:
FL-22: TOM Schedules (STD TASK Layout)

Act ID	Activity description	Cal ID	Hours to Complete	Cost to Complete	Early Start	Early Finish	May TFMR Finish	Orig Dur	Rem Dur	% Comp
LABORATORY ANALYSES										
MOD 01										
PQ0060110	Chemical Analysis	1	24.00	76,234.45	02SEP04	11OCT04	***04SEP04***	40	40	0
DATA MANAGEMENT										
MOD 01										
PQ0070120	Validation	2	158.00	3,353.50	15OCT04	11NOV04	***05OCT04***	20	20	0
PQ0070130	Database	2	175.00	3,434.57	12NOV04	09DEC04	***02NOV04***	20	20	0
PQ0070140	EGIS	2	133.00	2,770.45	09JAN04A	28DEC04	***22NOV04***	20	130	25
RISK ASSESSMENT REPORT										
MOD 01										
PQ0080100	Prepare Draft HHRA and ECO Risk Assessment	2	348.00	7,995.93	12NOV04	07FEB05	***29DEC04***	60	60	0
PQ0080125	Navy Review Draft HHRA & ECO Risk Assessment	1	0.00	0.00	08FEB05	09MAR05	***29JAN05***	30	30	0
PQ0080135	Prepare Final HHRA and ECO Risk Assessment	2	106.00	2,341.29	10MAR05	18MAY05	***08APR05***	50	50	0
RI / RFI REPORT										
MOD 01										
PQ0090105	Prepare Draft RI Report	2	583.00	13,219.31	12NOV04	07FEB05	***29DEC04***	60	60	0
PQ0090110	Navy Review Draft RI Report	1	0.00	0.00	08FEB05	09MAR05	***29JAN05***	30	30	0
PQ0090115	Prepare Draft-Final RI Report	2	250.00	5,734.17	10MAR05	06APR05	***25FEB05***	20	20	0



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Finish Date	03AUG05
Data Date	28JUN04
Run Date	08JUN04 07:48

Early Bar
Target Bar
Progress Bar
Critical Activity

NAVA - CX83 **Sheet 3 of 4**

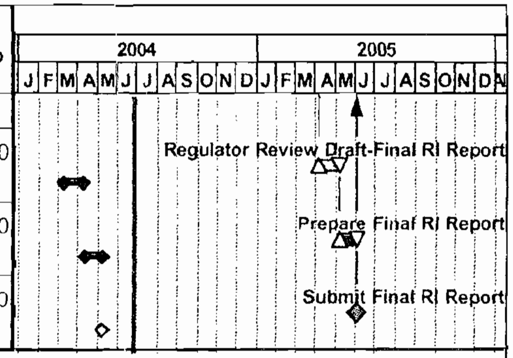
NAVY CLEAN III
T.O.M. SCHEDULE
PERIOD ENDING: 6/27/2004

TetraTech NUS

Layout:
LT-11: TOM Schedule Turnarounds (TASK)

Filter:
FL-22: TOM Schedules (STD TASK Layout)

Activity ID	Activity description	Cal ID	Hours to Complete	Cost to Complete	Early Start	Early Finish	May TFMR Finish	Orig Dur	Rem Dur	% Comp
MOD 01										
PQ0090120	Regulator Review Draft-Final RI Report	1	0.00	0.00	07APR05	06MAY05	***27MAR05***	30	30	0
PQ0090130	Prepare Final RI Report	2	78.00	1,733.23	09MAY05	03JUN05	***22APR05***	20	20	0
PQ0090132	Submit Final RI Report	2	0.00	0.00		03JUN05	***22APR05***	0	0	0



Start Date	31MAR95
Finish Date	03AUG05
Data Date	28JUN04
Run Date	08JUN04 07:48

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Early Bar
Target Bar
Progress Bar
Critical Activity

NAVA - CX83 Sheet 4 of 4

NAVY CLEAN III
T.O.M. SCHEDULE
PERIOD EN G: 6/27/2004

TetraTech NUS

Layout:
LT-11: TOM Schedule Turnarounds (TASK)

Filter:
FL-22: TOM Schedules (STD TASK Layout)

11.0 PROJECT MANAGEMENT

Day-to-day project management includes resource planning, monitoring, and control; Technical Financial Monthly Reports (TFMR) and review; routine internal review meetings and weekly reports; general communication with NAVFAC EFD SOUTH Navy, the installation, and subcontractors; and overall project oversight.

11.1 STAFFING

The Task Order Manager (TOM) for this project is Robert Fisher, PG. Mr. Fisher can be reached in the Tallahassee, Florida office by phone at (850) 385-9899, by facsimile at (850) 385-9860, and by email at fisherr@ttnus.com.

The Technical Lead and FOL for the Site 4 RI will be Bill Olsen, Geologist. Mr. Olsen is available at the Tallahassee, Florida office by phone at (850) 385-9899, by facsimile at (850) 385-9860, and by email at Olsenb@ttnus.com.

11.2 COORDINATION

The TOM will receive daily updates from the technical lead regarding the progression of project activities during the execution of the field investigation. The TOM and technical lead will be responsible for anticipating cost and schedule progression, and the TOM will relay these updates to the PMO and RPM on a weekly basis.

The TOM will provide project information to the public via the Restoration Advisory Board (RAB) meetings scheduled to coincide with project milestones (RI Report and the Action Memorandum review period).

12.0 REFERENCES

ABB-ES (ABB Environmental Services, Inc.) 1997. *Polychlorinated Biphenyl (PCB) Investigation Adjacent to the Parade Field, Naval Construction Battalion Center Gulfport, Gulfport, Mississippi*, Comprehensive Long-Term Environmental Action, Navy (CLEAN) Contract, Charleston, South Carolina.

CCI (CH2MHill Constructors, Inc.) 2000. *Source Removal Report for the Excavation of PCB Contaminated Soil from the Drainage Ditch Adjacent to the Parade Field, Naval Construction Battalion Center Gulfport, Gulfport, Mississippi*, Atlanta, Georgia.

MDEQ (Mississippi Department of Environmental Quality) 1999. *Tier I TRG Table*, Office of Pollution Control, Jackson, Mississippi

NEESA (Naval Energy and Environmental Support Activity) 1988. *Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Restoration Program*, NEESA 20.2-047B, Port Hueneme, California.

NFESC (Naval Facilities Engineering Service Center) 1996. *Navy Installation Restoration Laboratory Quality Assurance Guide* (Interim Document), Port Hueneme, California.

NFESO (Naval Facilities Engineering Services Office) 1999. *Southern Division Specifications for Monitoring Well Completion and Abandonment,* Port Hueneme, California.

TTNUS (Tetra Tech NUS, Inc.) 1999. *Comprehensive Quality Assurance Plan*, Tallahassee, Florida.

USEPA (U.S. Environmental Protection Agency) 1987. *Data Quality Objectives for Remedial Response Activities Development Process,* EPA 540/G-87/003A, Office of Emergency and Remedial Response, Directive 9355.0-7B, Washington, D.C.

USEPA (U.S. Environmental Protection Agency) 1993. *Guidance on Conducting Non-Time Critical Removal Actions Under CERCLA*, 540/R-93/057, Office of Emergency and Remedial Response, Washington, D.C.

USEPA (U.S. Environmental Protection Agency) 2000. *Close Out Procedures for National Priorities List Sites*, EPA/540/R/98/016, Office of Emergency and Remedial Response, Washington, D.C.

USEPA (U.S. Environmental Protection Agency) 1996b. *Environmental Investigations Standard Operating Procedure Quality Assurance Manual (EISOPQAM),* Environmental Compliance Branch, Region 4, Science and Ecosystems Support Division, Athens, Georgia.

USEPA (U.S. Environmental Protection Agency) 1999d. *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review,* EPA/540/R-94/012, Office of Emergency and Remedial Response, Washington, D.C.

USEPA (U.S. Environmental Protection Agency) 1994e. *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review,* EPA/540/R-94/013, Office of Emergency and Remedial Response, Washington, D.C.

APPENDIX A

DATA MANAGEMENT PLAN

1.0 INTRODUCTION

This document presents the DMP for NCBC Gulfport. The DMP describes the project-specific IMS, which consists of a relational database and Geographic Information System (GIS) that is being used to manage environmental information pertaining to the Base. The relational database stores chemical, geological, and hydrogeological data collected during environmental investigations. The GIS is built from the relational database and contains subsets of the larger data pool. Using the GIS, environmental data may be posted on base mapping to provide a spatial, graphical representation of the information. The GIS is used as a decision-making tool and to generate mapping for reports.

It is the responsibility of the Data Management Leader (DML) to populate and update the site-specific Data Catalog and distribute the most recent version to the project team. It is the responsibility of the TOM to ensure that the Data Catalog is accurate and current, and to notify the DML of any newly generated data that will support the needs of the project. It is the responsibility of the DML to update the TOM should any significant changes occur.

2.0 THE DATA FLOW PROCESS

Attachment 1 presents a flowchart describing, in general terms, the IMS data flow process from the analytical laboratory to the final end users. As shown, the data passes through the Sample Management Coordinator (SMC), the Data Validation Manager (DVM) and the DML before entering the master, project-specific database. This database is built and maintained using either Microsoft Access or SQL Server 7.0. The master database output is then routed into the GIS platform, which includes ArcView 3.2 and/or ArcInfo. In addition to database output, the GIS also accepts base mapping in many formats, including AutoCAD, Intergraph, DXF, and standard images formats. The GIS then generates output for various decision-making teams, report generation teams, Internet sites, and three-dimensional visualization using C-Tech's EVS Pro 3.0. Data contained within the relational database and GIS will be provided to third parties with prior approval from the Navy.

3.0 PROJECT PLANNING

At the beginning of each task order, the TOM shall call a kick-off meeting to outline the data needs of the task order. Attendees to the kick-off meeting shall include the TOM, the Human Health Risk Assessment (HHRA) Leader, the FOL, the Project Chemist, the DML, and the GIS Leader (GISL). The DML shall distribute a copy of the data management checklist (Attachment 2) and shall guide the project team through its contents. The data management checklist allows the project team to determine how the data will be managed and manipulated in order to achieve the project needs and objectives.

The DML and GISL leads may prepare a Needs Assessment and DQOs outline for the project. The Needs Assessment identifies the short-term and long-term data needs for the project. The Needs Assessment and DQO outline describes who the decision maker are, integration of existing data, how data will be collected, how data will be used, and how data will be presented.

4.0 NEWLY GENERATED DATA

When TtNUS is requested to collect new data at the project site, the TOM shall coordinate with the designated DML and GISL lead for the project. It is the responsibility of the FOL to comply with the sample and location nomenclature outlined in the site-specific work plan. It is also the responsibility of the FOL to coordinate with the GISL to ensure that all survey technical specifications are consistent with the underlying coordinate system in the GIS. The default coordinate system is State Plane Coordinate System (SPCS) - North American Datum (NAD) 1983 NAD83 for the horizontal and National Geodetic Vertical Datum (NGVD) 1988 for the vertical. Other systems may be used if appropriate for the site.

Prior to field mobilization, the FOL shall coordinate with the SMC to initiate the sample tracking and database creation process. A list of sample numbers, location names, laboratory analyses, and bottle requirements should be provided to the SMC for entry into the sample tracking database. The SMC will print a paper copy of the sample jar labels for the FOL to review. When requested, the final version of the sample jar labels will be printed onto labels and provided to the FOL prior to field mobilization. An advance paper copy of the labels and sample tracking database should be forwarded to the analytical laboratory for pre-login into the Laboratory Information Management System (LIMS).

Once field sampling is underway, the FOL shall forward a copy of the Chain-of-Custody (COC) to the SMC via facsimile at the end of each day. It is the responsibility of the TOM to ensure that this communication is taking place. The SMC shall compare the entries on the COCs to the sample tracking database and enter the sample date and sample depth (for soil samples). In the event that the SMC discovers a discrepancy between the sample tracking database and the COC, the SMC shall contact the TOM and FOL to resolve the discrepancy. In the event that a field change has taken place, the FOL is required to complete the Field Change Notification Form. In addition, the SMC is required to inform the laboratory project manager that a field change has taken place.

According to the laboratory technical specifications, the laboratory is required to deliver the analytical data in the TtNUS standard Electronic Data Deliverable (EDD) format (Attachment 3). Particular attention should be paid to the EDD requirements for validated vs. non-validated data. All EDDs shall be delivered to the SMC in the TtNUS Pittsburgh office. The SMC shall electronically query the EDDs against the sample tracking database to ensure that the laboratory has completed all samples and analyses. Once all samples and analyses have been accounted for, the SMC shall begin loading the analytical data into the relational database, which is located on the Local Area Network (LAN) in the TtNUS Pittsburgh office. The relational database structure is presented in Attachment 4. If the newly collected data are not to be validated, the relational database is created from the EDD. If the data are to be validated, the DVM shall print packages of data for each Sample Delivery Group (SDG) and analytical fraction (e.g., Volatile Organics) and distribute that package to the data validator. The data validator shall mark all data qualifiers and qualifier codes on the hardcopy printout and return to the DVM. The DVM will enter the data qualifiers and qualifier codes into the project database and print the final validated data for incorporation into the data validation letter. The DVM shall send an e-mail to the DML stating the data validation has been completed and the project database is complete and correct.

The DML and GISL shall coordinate with the TOM to outline the data and mapping requirements of the task. The DML shall create GIS-specific database tables as outlined in Attachment 5 and provide them to the GISL for loading into the ArcView-based Environmental GIS (EGIS). In order to ensure consistency, any and all changes or additions to the data shall be made in the project database only and filtered back into the GIS.

5.0 HISTORICAL DATA

In the event that hardcopy historical data must be incorporated into the project database, the TOM shall inform the DML of the data requirements. The DML shall review the hardcopy data and prepare a summary of the samples and analyses that will be entered. The format of the summary table should be similar to the sample tracking database. It is the responsibility of the TOM to review the sample summary table and verify that the entry of this data satisfies the project requirements. The DML shall physically edit the hardcopy analytical data to clearly designate which information on the hardcopy will be entered into the database. Copies of the marked-up data must be distributed to two separate parties for entry into Excel spreadsheets. Upon completion of the dual-key entry, the data management lead shall electronically compare the two data files to identify discrepancies and correct the data appropriately. The database should then be queried against the sample summary table to ensure that all pertinent data has been entered and checked for accuracy.

The DML shall coordinate with the GISL to acquire locational coordinates for each of the sample locations that will be entered. Historical sample location maps should be used to digitize the sample locations onto the GIS base-mapping layer. To the extent possible, the GISL shall capture, as metadata, the accuracy of the historical sample location maps used to digitize the location coordinates. If no sample location maps or other positional information exist for the historical data, the TOM should re-evaluate the utility of this data in the database.

6.0 MAPPING AND GRAPHICS

The GIS will utilize a standard coordinate system. If mapping or graphics are provided in another coordinate system, they must be converted to the standard system prior to integration into the GIS. In addition to (CADD) mapping, Digital Ortho Quarter Quads (DOQQs), Aerial Photography, and USGS 7.5 minute Quads may be obtained. As necessary, the images are warped to the predetermined coordinate system.

From survey data, sampling locations are organized, and then a sample-vs-location table is built. The sample locations are placed into standard database format, and then incorporated into the GIS.

7.0 GEOGRAPHIC INFORMATION SYSTEM

All environmental data collected in support of the project shall be incorporated into the GIS. The GIS is based on ArcView 3.2 and/or ArcInfo software, developed by the Environmental Software Research Institute (ESRI). The data structure of the ArcView GIS is presented in Attachment 5.

The GIS will demonstrate multi-application functionality to allow for quicker access to the information it contains. In other words, the GIS will be customized to enhance the speed and ease with which the user may move through the system and extract relevant information. This customization may be achieved through a multi-application process that utilizes ArcView and/or other software packages. The Avenue programming language has been used to create a customized EGIS application to facilitate decision-making by non-GIS staff.

8.0 ASSIMILATION OF DATA FROM OUTSIDE SOURCES

When environmental data is collected by a contractor other than TtNUS, it is the responsibility of the NAVFAC EFD SOUTH RPM to notify the TtNUS TOM. The RPM should forward a scope of work directing TtNUS to coordinate with the contractor and incorporate their data into the basewide database and GIS. To the extent possible, the RPM should direct the Navy Contractor to supply the data to TtNUS in the formats describe previously.

9.0 SOFTWARE

TtNUS will standardize on the following software packages when managing and manipulating data for the NAS Dallas project:

- Data Management - Microsoft Access, Visual FoxPro, and SQL Server 7.0
- GIS - ArcView 3.2, ArcInfo, and ArcIMS
- Geophysical 2-D Kriging - Geosoft Oasis Montaj
- 3-D Visualization – EVS Pro
- Geostatistics - GeoPack
- Groundwater Modeling - GMS
- Classical Statistics - Statistica 5.1
- Terrain Analysis - TerraModel 9.4.1
- Internet GIS - ESRI ArcIMS (Internet Map Server) 3.0
- Portable Document File (PDF) Generation – Adobe Acrobat Exchange

10.0 STORAGE OF DATA

TtNUS utilizes (NT) 4.0 for Networks as its network management system. The NT file system is backed up on a daily basis, thereby disallowing more than one day of work being lost should an accident occur. The database management and GIS groups have been allocated distinct drives on the LAN.

STANDARD OPERATING PROCEDURES (SOPS)

TETRA TECH NUS, INC.	STANDARD OPERATING PROCEDURES	Number CT-04	Page 1 of 6
		Effective Date 09/03	Revision 1
		Applicability Tetra Tech NUS, Inc.	
		Prepared Risk Assessment Department	
Subject SAMPLE NOMENCLATURE		Approved D. Senovich	

TABLE OF CONTENTS

SECTION **PAGE**

1.0 PURPOSE

The purpose of this document is to specify a consistent sample nomenclature system that will facilitate subsequent data management in a cost-effective manner. The sample nomenclature system has been devised such that the following objectives can be attained:

- Sorting of data by matrix.
- Sorting of data by depth.
- Maintenance of consistency (field, laboratory, and data base sample numbers).
- Accommodation of all project-specific requirements.
- Accommodation of laboratory sample number length constraints (maximum of 20 characters).

2.0 SCOPE

The methods described in this procedure shall be used consistently for all projects requiring electronic data.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Program Manager - It shall be the responsibility of the Program Manager (or designee) to inform contract-specific Project Managers of the existence and requirements of this Standard Operating Procedure.

Project Manager - It shall be the responsibility of the Project Manager to determine the applicability of this Standard Operating Procedure based on: (1) program-specific requirements, and (2) project size and objectives. It shall be the responsibility of the Project Manager (or designee) to ensure that the sample nomenclature is thoroughly specified in the relevant project planning document (e.g., sampling and analysis plan) and is consistent with this Standard Operating Procedure if relevant. It shall be the responsibility of the project manager to ensure that the Field Operations Leader is familiar with the sample nomenclature system.

Field Operations Leader - It shall be the responsibility of the Field Operations Leader to ensure that all field technicians or sampling personnel are thoroughly familiar with this Standard Operating Procedure and the project-specific sample nomenclature system. It shall be the responsibility of the Field Operations Leader to ensure that the sample nomenclature system is used during all project-specific sampling efforts.

5.0 PROCEDURES

5.1 Introduction

The sample identification (ID) system can consist of as few as 8 but not more than 20 distinct alpha-numeric characters. The sample ID will be provided to the laboratory on the sample labels and chain-of-custody forms. The basic sample ID provided to the lab has three segments and shall be as follows where "A" indicates "alpha," and "N" indicates "numeric":

A or N 3- or 4-Characters	AAA 2- or 3-Characters	A or N 3- to 6-Characters
Site Identifier	Sample Type	Sample Location

Additional segments may be added as needed. For example:

(1) Soil and Sediment Sample ID

A or N 3- or 4-Characters	AAA 2- or 3-Characters	A or N 3- to 6-Characters	NNNN 4-Characters
Site Identifier	Sample Type	Sample Location	Sample Depth

(2) Aqueous (groundwater or surface water) Sample ID

A or N 3- or 4-Characters	AAA 2- or 3-Characters	A or N 3- to 6-Characters	NN 2-Characters	-A
Site Identifier	Sample type	Sample Location	Round Number	Filtered Sample only

(3) Biota Sample ID

A or N 3- or 4-Characters	AAA 2- or 3-Characters	A or N 3- to 6-Characters	AA 2-Characters	NNN 3-Characters
Site Identifier	Sample Type	Sample Location	Species Identifier	Sample Group Number

5.2 Sample Identification Field Requirements

The various fields in the sample ID will include but are not limited to the following:

- Site Identifier
- Sample Type
- Sample Location
- Sample Depth
- Sampling Round Number
- Filtered
- Species Identifier
- Sample Group Number

The site identifier must be a three- or four-character field (numeric characters, alpha characters, or a mixture of alpha and numeric characters may be used). A site number is necessary since many facilities/sites have multiple individual sites, SWMUs, operable units, etc. Several examples are presented in Section 5.3 of this SOP.

The sample type must be a two- or three-character alpha field. Suggested codes are provided in Section 5.3 of this SOP.

The sample location must be at least a three-character field but may have up to six-characters (alpha, numeric, or a mixture). The six-characters may be useful in identifying a monitoring well to be sampled or describing a grid location.

The sample depth field is used to note the depth below ground surface (bgs) at which a soil or sediment sample is collected. The first two numbers of the four-number code specify the top interval, and the third and fourth specify the bottom interval in feet bgs of the sample. If the sample depth is equal to or greater than 100, then only the top interval would be represented and the sampling depth would be truncated to three-characters. The depths will be noted in whole numbers only; further detail, if needed, will be recorded on the sample log sheet, boring log, logbook, etc.

A two-digit round number will be used to track the number of aqueous samples taken from a particular aqueous sample location. The first sample collected from a location will be assigned the round identifier 01, the second 02, etc. This applies to both existing and proposed monitoring wells and surface water locations.

Aqueous samples that are field filtered (dissolved analysis) will be identified with an "-F" in the last field segment. No entry in this segment signifies an unfiltered (total) sample.

The species identifier must be a two-character alpha field. Several suggested codes are provided in Section 5.3 of this SOP.

The three digit sample group number will be used to track the number of biota sample groups (a particular group size may be determined by sample technique, media type, the number of individual caught, weight issues, time, etc.) by species and location. The first sample group of a particular species collected from a given location will be assigned the sample group number 001 and the second sample group of the same species collected from the same location will be assigned the sample group number 002.

5.3 Example Sample Field Designations

Examples of each of the fields are as follows:

Site Identifier - Examples of site numbers/designations are as follows:

A01 - Area of Concern Number 1
125 - Solid Waste Management Unit Number 125
000 - Base or Facility Wide Sample (e.g., upgradient well)
BBG - Base Background

The examples cited are only suggestions. Each Project Manager (or designee) must designate appropriate (and consistent) site designations for their individual project.

Sample Type - Examples of sample types are as follows:

AH - Ash Sample
AS - Air Sample
BM - Building Material Sample
BSB - Biota Sample Full Body
BSF - Biota Sample Fillet
CP - Composite Sample
CS - Chip Sample
DS - Drum Sample
DU - Dust Sample
FP - Free Product
IDW - Investigation Derived Waste Sample
LT - Leachate Sample
MW - Monitoring Well Groundwater Sample
OF - Outfall Sample
RW - Residential Well Sample
SB - Soil Boring Sample
SD - Sediment Sample
SC - Scrape Sample

SG - Soil Gas Sample
SL - Sludge Sample
SP - Seep Sample
SS - Surface Soil Sample
ST - Storm Sewer Water Sample
SW - Surface Water Sample
TP - Test Pit Sample
TW - Temporary Well Sample
WC - Well Construction Material Sample
WP - Wipe Sample
WS - Waste/Solid Sample
WW - Wastewater Sample

Sample Location - Examples of the location field are as follows:

001 - Monitoring Well 1
N32E92 - Grid location 32 North and 92 East
D096 - Investigation derived waste drum number 96

Species Identifier - Examples of species identifier are as follows:

BC - Blue Crab
GB - Blue Gill
CO - Corn
SB - Soybean

5.4 Examples of Sample Nomenclature

The first round monitoring well groundwater sample collected from existing monitoring well 001 at SWMU 16 for a filtered sample would be designated as 016MW00101-F.

The second round monitoring well groundwater sample collected from existing monitoring well C20P2 at Site 23 for an unfiltered sample would be designated as 023MWC20P202.

The second surface water sample collected from point 01 at SWMU 130 for an unfiltered sample would be designated as 130SW00102.

A surface soil sample collected from grid location 32 North and 92 East at Site 32 at the 0- to 2-foot interval would be designated as 032SSN32E920002.

A subsurface soil sample from soil boring 03 at SWMU 32 at an interval of 4 to 5 feet bgs would be designated as 032SB0030405.

A sediment sample collected at SWMU 19 from 0 to 6 inches at location 14 would be designated as 019SD0140001. The sample data sheet would reflect the precise depth at which this sample was collected.

During biota sampling for full body analysis the first time a minnow trap was checked at grid location A25 of SWMU 1415 three small blue gills were captured, collected and designated with the sample ID of 1415BSBA25BG001. The second time blue gill were collected at the same location (grid location A25 at SWMU 1415) the sample ID designation given was 1415BSBA25BG002.

Note: No dash (-) or spacing is used between the segments with the exception of the filtered segment. The "F" used for a filtered aqueous sample is preceded by a dash "-F".

5.5 Field Quality Assurance/Quality Control (QA/QC) Sample Nomenclature)

Field QA/QC will be designated using a different coding system. The QC code will consist of a three- to four-segment alpha-numeric code that identifies the sample QC type, the date the sample was collected, and the number of this type of QC sample collected on that date.

AA	NNNNNN	NN	-F
QC Type	Date	Sequence Number (per day)	Filtered (aqueous only, if needed)

The QC types are identified as:

TB = Trip Blank
RB = Rinsate Blank (Equipment Blank)
FD = Field Duplicate
AB = Ambient Conditions Blank
WB = Source Water Blank

The sampling time recorded on the Chain-of-Custody Form, labels, and tags for duplicate samples will be 0000 so that the samples are "blind" to the laboratory. Notes detailing the sample number, time, date, and type will be recorded on the routine sample log sheets and will document the location of the duplicate sample (sample log sheets are not provided to the laboratory). Documentation for all other QC types (TB, RB, AB, and WB) will be recorded on the QC Sample Log sheet (see SOP on Field Documentation).

5.6 Examples of Field QA/QC Sample Nomenclature

The first duplicate of the day for a filtered ground water sample collected on June 3, 2000 would be designated as FD06030001-F.

The third duplicate of the day taken of a subsurface soil sample collected on November 17, 2003 would be designated as FD11170303.

The first trip blank associated with samples collected on October 12, 2000 would be designated as TB10120001.

The only rinsate blank collected on November 17, 2001 would be designated as RB11170101.

6.0 DEVIATIONS

Any deviation from this SOP must be addressed in detail in the site specific planning documents.

ATTACHMENT 2

DATABASE CHECKLIST

Checklist (pg 1)

Checklist (pg 2)

Checklist (pg 3)

Checklist (pg 4)

Checklist (pg 5)

ATTACHMENT 3

ELECTRONIC DATA DELIVERABLE (EDD) REQUIREMENTS FOR ANALYTICAL LABORATORIES

1.0 INTRODUCTION

The laboratory is to provide 3.5" high density diskette(s) containing separate database (DBF) files in the format specified in this Attachment. The electronic deliverable includes all environmental samples, sample dilutions, sample reanalyses, and laboratory quality control samples. **All entries in the electronic deliverable must agree exactly with the final entries reported on the hardcopy data package sample result summaries**. Any corrections made to the hardcopy data must also be made to the electronic file. Appropriate qualifiers as identified by the analytical protocol must also be designated; laboratory QC non-compliance codes are not to be depicted.

Each diskette is to be properly labeled with the laboratory name, project name, file name(s), and laboratory point of contact. Electronic files should be delivered in the same fashion as are the hard copy data packages. A separate .dbf file shall be made for each analytical fraction (by method) and each SDG. The files shall be named with the first character being the analytical fraction designator, followed by an underscore, followed by the SDG name. For example, the file for the volatile fraction for SDG BR001 should be named V_BR001.DBF. Additionally, the laboratory must provide a hardcopy listing all electronic files saved to the diskette, indicating what analytical fraction and matrix the file data contained therein pertain to. All electronic data deliverables are due within the same time established for the associated hardcopy data packages.

In addition, the laboratory QC officer must read and sign a copy of the Quality Assurance Review Form displayed on the next page of this Attachment. Electronic deliverables are not considered to be complete without the accompanying Quality Assurance Review Form.

I ______________________________________, as the designated Quality Assurance Officer, hereby attest that all electronic deliverables have been thoroughly reviewed and are in agreement with the associated hardcopy data. The enclosed electronic files have been reviewed for accuracy (including significant figures), completeness and format. The laboratory will be responsible for any labor time necessary to correct enclosed electronic deliverables that have been found to be in error. I can be reached at ( )_____________if there are any questions or problems with the enclosed electronic deliverables.

Signature:__________________________ Title:________________________ Date:________________

The analytical data shall be delivered electronically in a Dbase III file format (filename.dbf). The exact structure of the database is described in the table below. It shall be the responsibility of the laboratory to ensure that all electronic entries are in strict accordance with the information provided on the Form I.

An example database shall be sent for review prior to the first electronic deliverable in Dbase III format. The example file will be examined for completeness and comments will be sent to the laboratory. Any questions regarding the electronic deliverable shall be directed to Ricky DePaul at Tetra Tech NUS (412)921-7112.

DATA FIELD	DATA TYPE	FIELD WIDTH	DATA FIELD DESCRIPTION
SAMPLE_NO	C	25	Field sample ID as listed on the chain-of-custody. The sample number indicated in this field should never be truncated. The only exception for this field not matching the chain-of-custody is for reanalyses and matrix spike results in which a RE or MS suffix will be added to the sample number respectively.
TRUNCATE	C	15	If the field sample ID listed on the Chain of Custody is truncated by the laboratory for use with the laboratory software, the truncated sample ID should appear in this field.
LAB_ID	C	15	Laboratory number for the given sample.
LABORATORY	C	25	Laboratory name.
BATCH_NO	C	10	Laboratory code for batch of samples included in a given run.
ASSOC_BLNK	C	15	Laboratory name of the method blank associated with that particular batch of samples.
QC_TYPE	C	15	Normal Environmental Sample = “NORMAL”, Laboratory Duplicate = “DUPLICATE”, Matrix Spike = “MS”, Matrix Spike Duplicate = “MSD”, Laboratory Control Sample = “LCS”, Laboratory Control Sample Duplicate = “LCSD”, Method Blank = “M_BLANK”, Preparation Blank = “P_BLANK”.
SAMP_DATE	D	8	Date of sample collection as indicated on the Chain of Custody. Example: 11/07/93.
REC_DATE	D	8	Date sample was received by the laboratory.
EXTR_DATE	D	8	Date sample was extracted or prepared by the laboratory.
ANAL_DATE	D	8	Date sample was analyzed by the laboratory.
RUN_NUMBER	N	2 (0)	The number of the analytical run for a given sample in sequence. For example, if a sample is diluted and reanalyzed, the original run number would be 1 and the reanalysis would be 2.
SDG	C	15	Sample delivery group identifier assigned by the laboratory. This number should <u>exactly</u> match the SDG designated on the hardcopy data package.
PROJECT_NO	C	10	Identification of Project Number or CLEAN Task Order (CTO) number.
PROJ_MNGR	C	25	The Tetra Tech NUS Project Manager’s last name, followed by a comma, followed by the first initial of the Project Manager (e.g. Hutson, D).

DATA FIELD	DATA TYPE	FIELD WIDTH	DATA FIELD DESCRIPTION
PARAMETER	C	45	Chemical or analyte name exactly as reported on Form I.
CAS_NO	C	10	Chemical Abstract Service number for the parameter listed. The CAS number should be reported exactly as it is listed in publications such as the Merck Index. This field should be left blank for those parameters not having CAS numbers (e.g. Total Organic Carbon).
FRACTION	C	5	Metals = 'M', Volatiles = 'OV', Semivolatiles/BNAs = 'OS', Pesticides = 'PEST', Herbicides = 'HERB', Polychlorinated Biphenyls = 'PCB', Explosives = 'EXP', Any petroleum hydrocarbon or fuel = 'TPH', Wet Chemistry = 'WET', Radionuclide = 'RAD', Miscellaneous = 'MISC'
METHOD	C	20	Analytical method used to quantitate parameter concentrations as listed in the laboratory technical specification (e.g. '8270A' for SW-846 Method 8270A.
LAB_RESULT	N	20 (6)	Reported value in units specified in the UNITS field containing the proper number of significant digits. The % Recovery shall be placed in this field for matrix spike and laboratory control sample results.
UNITS	C	5	The units of measure as reported on the Form I.
LAB_QUAL	C	2	The laboratory qualifier as reported on the Form I. For example, a 'U' qualifier should be used for all nondetected results.
IDL	N	15 (6)	Instrument detection limit in units specified in the UNITS field.
MDL	N	15 (6)	Method detection limit in units specified in the UNITS field and method specified in the METHOD field.
CRDL_CRQL	N	15 (6)	Contract Required Detection/Quantitation Limit in the units specified in the UNITS field. RDL for non-CLP parameters.
DIL_FACTOR	N	6 (1)	Dilution factor.
PCT_MOIST	N	5 (1)	Percent moisture for soil samples; blank for water samples.
COMMENTS	C	20	Analytical result qualifier or comment other than that listed in the LAB_QUAL field. Example: 'Reanalysis'.

C = Character string (everything shall be reported in capital letters)
N = Numeric string (decimal places are in parentheses in field width column)
D = Date (Ex: 05/25/97)

ATTACHMENT 4

DATABASE STRUCTURE

ATTACHMENT 5

ARCVIEW GIS DATA STRUCTURE

1.0 INTRODUCTION

This document describes the table structures and field descriptions of the database used in the Environmental Geographic Information System (EGIS). Electronic data interchange (EDI) tools can improve the quality and timeliness of data exchange, establish consistent methods, streamline processes and procedures, and reduce costs while increasing the effectiveness information. As part of this effort the EGIS was designed by Tetra Tech NUS, Inc. (TtNUS) to combine the power and versatility of a relational database management system and a user-friendly Geographic Information System (GIS) interface. The EGIS allows integration of a facility's environmental information with real-world images and drawings. This accessibility provides easy, real-time access to an organization's environmental data.

2.0 TABLE STRUCTURES

The EGIS database table structures are defined and discussed below in Tables 2.1 – 2.3. This information is provided for users who want to manipulate the data beyond the EGIS application, using another database or application

TABLE 2.1

FILE STRUCTURE AND DEFINITIONS FOR PROJECT

The Project document is a single dBASE file containing specific information about the project.

FIELD	FIELD TYPE	DESCRIPTION
PrjNo	Character (25)	Unique facility number assigned to each facility
Facility	Character (25)	The name of the facility the data is associated with
Path	Character (25)	Directory storing all data related to the facility
PIC	Character (25)	Internal principle in charge or project manager
Phone	Character (15)	Phone number of PIC
Email	Character (35)	Email address of PIC
Projection	Character (40)	Coordinate system used for all spatial data
Datum	Character (15)	Datum used by the projection
SubmitDate	Date	Date the project was submitted

TABLE 2.2

FILE STRUCTURE AND DEFINITIONS FOR LOCATIONS

The locations file structure format used to develop dBASE tables containing location information for specific sample matrices. Each unique matrix has its own unique table (i.e. loc_gw.dbf, loc_so.dbf, etc.)

FIELD	FIELD TYPE	DESCRIPTION
LocID	Character (25)	The commonly used unique identification of each location
LocName	Character (25)	The commonly used name of each location
Northing	Numeric (15,4)	Northing (Y) Coordinate System location for each LocID point
Easting	Numeric (15,4)	Easting (X) Coordinate System location for each LocID point
GElevation	Numeric (10,4)	Ground surface elevation (MSL) of LocID
InstlDate	Date	Installation date of LocID
Type	Character (4)	Indicates the type of location by the LocID
OU	Character (5)	Operable Unit number
SWMU	Character (5)	Solid Waste Management Unit number
AOC	Character (20)	Area of concern
Site	Character (25)	The designated site number
LocAlias	Character (25)	An alternative identification for LocID

TABLE 2.3 –

FILE STRUCTURE AND DEFINITIONS FOR RESULTS

The results file structure format used to develop dBASE tables containing result information for its perspective sample location matrix (i.e. res_gw.dbf, res_so.dbf, etc.).

FIELD	FIELD TYPE	DESCRIPTION
LocID	Character (25)	The commonly used unique identification of each location.
SampleID	Character (35)	Unique identification number for each distinct sample collected in the field, for a specific sampling day or episode.
CAS	Character (12)	Chemical Abstract Service number.
Parameter	Character (50)	Indicates the analyte, parameter or chemical name for which results are being presented.
Result	Character (20)	Result, concentration, or value of the analyte, parameter or chemical in a numeric format.
Unit	Character (5)	Unit of measurement for the Result.
Qualifier	Character (3)	Validation qualifier
Fraction	Character (10)	Chemical class or fraction type.
Matrix	Character (4)	Indicates the matrix represented by the sample.
DepthTop	Numeric (10,4)	Depth to the top of the sample, measured from ground surface.
DepthBot	Numeric (10,4)	Depth to the bottom of the sample, measured from ground surface.
SampleDate	Date	The date the sample was collected in the field
Round	Character (5)	Interval description of sample data collected within a finite period of time. For multiple rounds of sampling, this field may contain the year and round number (i.e. 20001)
Duplicate	Character (10)	Code for reference to field duplicates.

TABLE OF CONTENTS

1.0 PURPOSE

This procedure describes methods and equipment commonly used for collecting environmental samples of surface water and aquatic sediment for either onsite examination and chemical testing, or for subsequent laboratory analysis.

2.0 SCOPE

The information presented in this guideline is generally applicable to all environmental sampling of surface waters (Section 5.3) and aquatic sediments (Section 5.5), except where the analyte(s) may interact with the sampling equipment. The collection of concentrated sludges or hazardous waste samples from disposal or process lagoons often requires methods, precautions and equipment different from those described herein.

3.0 GLOSSARY

Environmental Sample - a sample containing (or suspected to contain) low-level concentrations of contaminants, which does not require special handling or transport considerations as detailed in SOP SA-6.1.

Hazardous Waste Sample - a sample containing (or suspected to contain) higher concentrations of contaminants thus requiring special handling and/or transport considerations per SOP SA-6.1.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager has the overall responsibility for seeing that all surface water and sediment sampling activities are properly conducted by appropriately trained personnel.

Field Operations Leader - The Field Operations Leader (FOL) is responsible for the supervision of onsite water quality analyses, ensuring proper sample collection, handling, and the completion and accuracy of all field documentation, and making sure that custody of all samples obtained is maintained according to proper procedures.

5.0 PROCEDURES

5.1 Introduction

Collecting a representative sample from surface water or sediments is difficult because of water movement, stratification, or patchiness. To collect representative samples, one must standardize sampling bias related to site selection, sampling frequency, sample collection, sampling devices, and sample handling, preservation, and identification.

Representativeness is a qualitative description of the degree to which an individual sample accurately reflects population characteristics or parameter variations at a sampling point. It is therefore an important characteristic not only of assessment and quantification of environmental threats posed by the site, but also for providing information for engineering design and construction. Proper sample location selection and proper sample collection methods are important to ensure that a truly representative sample has been taken. Regardless of quality control applied during laboratory analyses and subsequent scrutiny of analytical data packages, reported data are no better than the confidence that can be placed in the representativeness of the samples.

5.2 Defining the Sampling Program

Many factors must be considered in developing a sampling program for surface water or sediments including study objectives, accessibility, site topography, physical characteristics of the water body (such as flow and mixing), point and diffuse sources of contamination, and personnel and equipment available to conduct the study. For waterborne constituents, dispersion depends on the vertical and lateral mixing within the body of water. For sediments, dispersion depends on bottom current or flow characteristics, sediment characteristics (density, size) and geochemical properties (which affect adsorption/desorption). The hydrogeologist developing the sampling plan must therefore know not only the mixing characteristics of streams and lakes, but also must understand the role of fluvial-sediment transport, deposition, and chemical sorption.

5.2.1 Sampling Program Objectives

The objective of surface water sampling is to determine the surface water quality entering, leaving or remaining within the site. The scope of the sampling program must consider the sources and potential pathways for transport of contamination to or within a surface water body. Sources may include point sources (leaky tanks, outfalls, etc.) or nonpoint sources (e.g., spills). The major pathways for surface water contamination (not including airborne deposition) are overland runoff, leachate influx to the waterbody, direct waste disposal (solid or liquid) into the water body; and groundwater flow influx from upgradient. The relative importance of these pathways, and therefore the design of the sampling program, is controlled by the physiographic and hydrologic features of the site, the drainage basin(s) which encompass the site, and the history of site activities.

Physiographic and hydrologic features to be considered include slopes and runoff direction, areas of temporary flooding or pooling, tidal effects, artificial surface runoff controls such as berms or drainage ditches (and when they were constructed relative to site operation), and locations of springs, seeps, marshes, etc. In addition, the obvious considerations such as the location of man-made discharge points to the nearest stream (intermittent or flowing), pond, lake, estuary, etc., shall be considered.

A more subtle consideration in designing the sampling program is the potential for dispersion of dissolved or sediment-associated contaminants away from the source. The dispersion could lead to a more homogeneous distribution of contamination at low or possibly non-detectable concentrations. Such dispersion does not, however, always readily occur. For example, obtaining a representative sample of contamination from a main stream immediately below an outfall or a tributary is difficult because the inflow frequently follows a stream bank with little lateral mixing for some distance. Sampling alternatives to overcome this situation are: (1) move the site far enough downstream to allow for adequate mixing, or (2) collect integrated samples in a cross section. Also, nonhomogeneous distribution is a particular problem with regard to sediment-associated contaminants, which may accumulate in low-energy environments (coves, river bends, deep spots, or even behind boulders) near or distant from the source while higher-energy areas (main stream channels) near the source may show no contaminant accumulation.

The distribution of particulates within a sample itself is an important consideration. Many organic compounds are only slightly water soluble and tend to adsorb onto particulate matter. Nitrogen, phosphorus, and the heavy metals may also be transported by particulates. Samples must be collected with a representative amount of suspended material; transfer from the sampling device shall include transferring a proportionate amount of the suspended material.

5.2.2 Location of Sampling Stations

Accessibility is the primary factor affecting sampling costs. The desirability and utility of a sample for analysis and consideration of site conditions must be balanced against the costs of collection as controlled by accessibility. Bridges or piers are the first choice for locating a sampling station on a stream, because bridges provide ready access and also permit the sampling technician to sample any point across the stream. A boat or pontoon (with an associated increase in cost) may be needed to sample locations on lakes and reservoirs, as well as those on larger rivers. Frequently, however, a boat will take longer to cross a water body and will hinder manipulation of the sampling equipment. Wading for samples is not recommended unless it is known that contaminant levels are low so that skin contact will not produce adverse health effects. This provides a built in margin of safety in the event that wading boots or other protective equipment should fail to function properly. If it is necessary to wade into the water body to obtain a sample, the sampler shall be careful to minimize disturbance of bottom sediments and must enter the water body downstream of the sampling location. If necessary, the sampling technician shall wait for the sediments to settle before taking a sample.

Sampling in marshes or tidal areas may require the use of an all-terrain vehicle (ATV). The same precautions mentioned above with regard to sediment disturbance apply.

Under ideal and uniform contaminant dispersion conditions in a flowing stream, the same concentrations of each would occur at all points along the cross section. This situation is most likely downstream of areas of high turbulence. Careful site selection is needed in order to ensure, as nearly as possible, that samples are taken where uniform flow or deposition and good mixing conditions exist.

The availability of streamflow and sediment discharge records can be an important consideration in choosing sampling sites in streams. Streamflow data in association with contaminant concentration data are essential for estimating the total contaminant loads carried by the stream. If a gaging station is not conveniently located on a selected stream, the project hydrogeologist shall explore the possibility of obtaining streamflow data by direct or indirect methods.

5.2.3 Frequency of Sampling

The sampling frequency and the objectives of the sampling event will be defined by the project plan documents. For single-event site or area characterization sampling, both bottom material and overlying water samples shall be collected at the specified sampling stations. If valid data are available on the distribution of the contaminant between the solid and aqueous phases, it may be appropriate to sample only one phase, although this is not often recommended. If samples are collected primarily for monitoring purposes (i.e., consisting of repetitive, continuing measurements to define variations and trends at a given location), water samples shall be collected at a pre-established and constant interval as specified in the project plans (often monthly or quarterly, and during droughts and floods). Samples of bottom material shall be collected from fresh deposits at least yearly, and preferably seasonally, during both spring and fall.

The variability in available water-quality data shall be evaluated before determining the number and collection frequency of samples required to maintain an effective monitoring program.

5.3 Surface Water Sample Collection

5.3.1 Streams, Rivers, Outfalls and Drainage Features (Ditches, Culverts)

Methods for sampling streams, rivers, outfalls, and drainage features at a single point vary from the simplest of hand-sampling procedures to the more sophisticated multi-point sampling techniques known as the equal-width-increment (EWI) method or the equal-discharge-increment (EDI) methods (see below).

Samples from different depths or cross-sectional locations in the watercourse taken during the same sampling episode, shall be composited. However, samples collected along the length of the watercourse or at different times may reflect differing inputs or dilutions and therefore shall not be composited.

Generally, the number and type of samples to be taken depend on the river's width, depth, discharge and on the suspended sediment the stream or river transports. The greater the number of individual points that are sampled, the more likely that the composite sample will truly represent the overall characteristics of the water.

In small streams less than about 20 feet wide, a sampling site can generally be found where the water is well mixed. In such cases, a single grab sample taken at mid-depth in the center of the channel is adequate to represent the entire cross section.

For larger streams, at least one vertical composite shall be taken with one sample each from just below the surface, at mid-depth, and just above the bottom. The measurement of DO, pH, temperature, conductivity, etc., shall be made on each aliquot of the vertical composite and on the composite itself. For rivers, several vertical composites shall be collected, as directed in the project plan documents.

5.3.2 Lakes, Ponds and Reservoirs

Lakes, ponds, and reservoirs have a much greater tendency to stratify than rivers and streams. The relative lack of mixing requires that more samples be obtained.

The number of water sampling sites on a lake, pond, or impoundment will vary with the size and shape of the basin. In ponds and small lakes, a single vertical composite at the deepest point may be sufficient. Similarly, the measurement of DO, pH, temperature, etc., is to be conducted on each aliquot of the vertical composite and on the composite itself. In naturally-formed ponds, the deepest point may have to be determined empirically; in impoundments, the deepest point is usually near the dam.

In lakes and larger reservoirs, several vertical composites shall be composited to form a single sample. These verticals are often taken along a transect or grid. In some cases, it may be of interest to form separate composites of epilimnetic and hypolimnetic zones. In a stratified lake, the epilimnion is the thermocline which is exposed to the atmosphere. The hypolimnion is the lower, "confined" layer which is only mixed with the epilimnion and vented to the atmosphere during seasonal "overturn" (when density stratification disappears). These two zones may thus have very different concentrations of contaminants if input is only to one zone, if the contaminants are volatile (and therefore vented from the epilimnion but not the hypolimnion), or if the epilimnion only is involved in short-term flushing (i.e., inflow from or outflow to shallow streams). Normally, however, a composite consists of several verticals with samples collected at various depths.

In lakes with irregular shape and with bays and coves that are protected from the wind, separate composite samples may be needed to adequately represent water quality since it is likely that only poor mixing will occur. Similarly, additional samples are recommended where discharges, tributaries, land use characteristics, and other such factors are suspected of influencing water quality.

Many lake measurements are now made in-situ using sensors and automatic readout or recording devices. Single and multi-parameter instruments are available for measuring temperature, depth, pH, oxidation-reduction potential (ORP), specific conductance, dissolved oxygen, some cations and anions, and light penetration.

5.3.3 Estuaries

Estuarine areas are by definition, zones where inland freshwaters (both surface and ground) mix with oceanic saline waters. Estuaries are generally categorized into three types dependent upon freshwater inflow and mixing properties. Knowledge of the estuary type is necessary to determine sampling locations. Each type of estuarine area is described below:

- Mixed Estuary - characterized by the absence of a vertical halocline (gradual or no marked increase in salinity in the water column) and a gradual increase in salinity seaward. Typically this type of estuary is shallow and is found in major freshwater sheetflow areas. Being well mixed, the sampling locations are not critical in this type of estuary.

- Salt Wedge Estuary - characterized by a sharp vertical increase in salinity and stratified freshwater flow along the surface. In these estuaries, the vertical mixing forces cannot override the density differential between fresh and saline waters. In effect, a salt wedge tapering inland moves horizontally, back and forth, with the tidal phase. If contamination is being introduced into the estuary from upstream, water sampling from the salt wedge may miss it entirely.

- Oceanic Estuary - characterized by salinities approaching full-strength oceanic waters. Seasonally, freshwater inflow is small with the preponderance of the fresh-saline water mixing occurring near, or at, the shore line.

Sampling in estuarine areas is normally based upon the tidal phases, with samples collected on successive slack tides (i.e., when the tide turns). Estuarine sampling programs shall include vertical salinity measurements at 1- to 5-foot increments, coupled with vertical dissolved oxygen and temperature profiles.

5.3.4 Surface Water Sampling Equipment

The selection of sampling equipment depends on the site conditions and sample type to be acquired. The most frequently used samplers are:

- Open tube.
- Dip sampler.
- Weighted bottle.
- Hand pump.
- Kemmerer.
- Depth-Integrating Sampler.

The dip sampler and the weighted bottle sampler are used most often, and detailed discussions for these devices only (and the Kemmerer sampler) are addressed subsequently in this section.

The criteria for selecting a sampler include:

1. Disposability and/or easy decontamination.
2. Inexpensive cost (if the item is to be disposed).
3. Ease of operation.
4. Nonreactive/noncontaminating properties - Teflon-coated, glass, stainless-steel or PVC sample chambers are preferred (in that order).

As specified above, each sample (grab or each aliquot collected for compositing) shall be measured for but not limited to:

- Specific conductance.
- Temperature.
- pH.
- Dissolved oxygen (optional).

Sample measurements shall be conducted as soon as the sample is acquired. Measurement techniques described in SOP SA-1.1 shall be followed. All pertinent data and results shall be recorded in a field notebook or on sample logsheets (see Attachment A). These analyses will provide information on water mixing/stratification and potential contamination.

Dip Sampling

Water is often sampled by filling a container either attached to a pole or held directly, from just beneath the surface of the water (a dip or grab sample). Constituents measured in grab samples are only indicative of conditions near the surface of the water and may not be a true representation of the total concentration that is distributed throughout the water column and in the cross section. Therefore, whenever possible, it is recommended to augment dip samples with samples that represent both dissolved and suspended constituents and both vertical and horizontal distributions.

Weighted Bottle Sampling

A grab sample can also be taken using a weighted holder that allows a bottle to be lowered to any desired depth, opened for filling, closed, and returned to the surface. This allows discrete sampling with depth. Several of these samples can be combined to provide a vertical composite. Alternatively, an open bottle can be lowered to the bottom and raised to the surface at a uniform rate so that the bottle collects sample throughout the total depth and is just filled on reaching the surface. The resulting sample using either method will roughly approach what is known as a depth-integrated sample.

A closed weighted bottle sampler consists of a stopped glass or plastic bottle, a weight and/or holding device, and lines to open the stopper and lower or raise the bottle. The procedure for sampling with this device is:

- Gently lower the sampler to the desired depth so as not to remove the stopper prematurely (watch for bubbles).
- Pull out the stopper with a sharp jerk of the stopper line.
- Allow the bottle to fill completely, as evidenced by the absence of air bubbles.
- Raise the sampler and cap the bottle.
- Decontaminate the outside of the bottle. This bottle can be used as the sample container as long as the bottle is an approved container type.

Kemmerer

If samples are desired at a specific depth, and the parameters to be measured do not require a Teflon coated sampler, a standard Kemmerer sampler may be used. The Kemmerer sampler is a brass, stainless-steel or acrylic cylinder, with rubber stoppers that leave the ends open while being lowered in a vertical position (thus allowing free passage of water through the cylinder). A "messenger" is sent down the line when the sampler is at the designated depth, to cause the stoppers to close the cylinder, which is then raised. Water is removed through a valve to fill sample bottles.

5.3.5 Surface Water Sampling Techniques

Most samples taken during site investigations are grab samples. Typically, surface water sampling involves immersing the sample container in the body of water; however, the following suggestions are made to help ensure that the samples obtained are representative of site conditions:

- The most representative samples are obtained from mid-channel at a 0.6 foot stream depth in a well-mixed stream.

- Even though the containers used to obtain the samples are previously laboratory cleaned, it is suggested that the sample container be rinsed at least once with the water to be sampled before the sample is taken. This is not applicable when sample containers are provided "pre-preserved."

- For sampling moving water, it is suggested that the farthest downstream sample be obtained first, and that subsequent samples be taken as one works upstream. In general, work from zones suspected of low contamination to zones of high contamination.

- To sample a pond or other standing body of water, the surface area may be divided into grids. A series of samples taken from each grid node is combined into one sample, or several grid nodes are selected at random.

- Care should be taken to avoid excessive agitation of the water, as loss of volatile constituents could result.

- When obtaining samples in 40 mL septum vials for volatile organics analysis, it is important to exclude any air space in the top of the bottle and to be sure that the Teflon liner of the septum faces in after the vial is filled and capped. The vial can be turned upside down to check for air bubbles.

- Do not sample at the surface, unless sampling specifically for a known constituent which is immiscible and on top of the water. Instead, the sample container should be inverted, lowered to the approximate depth, and held at about a 45-degree angle with the mouth of the bottle facing upstream. When sample containers are provided "pre-preserved," use a dedicated, clean, un-preserved bottle for sampling and transfer to an appropriately-preserved container.

5.4 Onsite Water Quality Testing

Onsite water quality testing shall be conducted as described in SOP SA-1.1.

5.5 Sediment Sampling

5.5.1 General

Sediment samples are usually collected at the same verticals at which water samples were collected. If only one sediment sample is to be collected, the sampling location shall be approximately at the center of the water body.

Generally, the coarser grained sediments are deposited near the headwaters of the reservoir. Bed sediments near the center of a water body will be composed of fine-grained materials which may, because of their lower porosity and greater surface area available for adsorption, contain greater concentrations of contaminants. The shape, flow pattern, bathometry (i.e., depth distribution), and water circulation patterns must all be considered when selecting sediment sampling sites. In streams, areas likely to have sediment accumulation (e.g., bends, behind islands or boulders, quiet shallow areas or very deep, low-velocity areas) shall be sampled while areas likely to show net erosion (i.e., high-velocity, turbulent areas) and suspension of fine solid materials, shall be avoided.

Chemical constituents associated with bottom material may reflect an integration of chemical and biological processes. Bottom samples reflect the historical input to streams, lakes, and estuaries with respect to time, application of chemicals, and land use. Bottom sediments (especially fine-grained material) may act as a sink or reservoir for adsorbed heavy metals and organic contaminants (even if water column concentrations are below detection limits). Therefore, it is important to minimize the loss of low-density "fines" during any sampling process.

All relevant information pertaining to sediment sampling shall be documented as applicably described in SOP SA-6.3 and Attachment B.

5.5.2 Sampling Equipment and Techniques

A bottom-material sample may consist of a single scoop or core, or may be a composite of several individual samples in the cross section. Sediment samples may be obtained using onshore or offshore techniques.

The following health and safety provisions apply when working on/over/near water.

Size of Work Team:

1) Never less than 2 persons [who are wearing USCG approved Personal Flotation Devices (PFDs)]

2) A minimum of 3 persons if <u>*any*</u> of the following conditions are anticipated or observed:

   - Depth is greater than 3 feet
   - Involves a waterway that is turbulent <u>*or*</u> swift
   - The underwater walking surface (e.g., stream/river bed) is suspected or observed to involve conditions that increase the potential for a worker to fall into the water. Examples would include large/uneven rocks or boulders, dense mud or sediment that could entrap worker's feet, etc.)
   - Waterway is tidal, and conditions such as those listed above could change

The third person in the above condition must be equipped and prepared to render emergency support [e.g., lifeline, tethered PFD (life saver), skiff, means to contact external emergency response support, etc.]

The following samplers may be used to collect bottom materials:

- Scoop sampler.
- Dredge samplers.

Each type of sampler is discussed subsequently.

<u>Scoop Sampler</u>

A scoop sampler consists of a pole to which a jar or scoop is attached. The pole may be made of bamboo, wood, PVC, or aluminum and be either telescoping or of fixed length. The scoop or jar at the end of the pole is usually attached using a clamp.

If the water body can be sampled from the shore or if it can be waded, the easiest and best way to collect a sediment sample is to use a scoop sampler. This reduces the potential for cross-contamination. This method is accomplished by reaching over or wading into the water body and, while facing upstream (into the current), scooping the sampler along the bottom in an upstream direction. It is very difficult not to disturb fine-grained materials of the sediment-water interface when using this method.

Dredges

Dredges are generally used to sample sediments which cannot easily be obtained using coring devices (i.e., coarse-grained or partially-cemented materials) or when large quantities of sample are required. Dredges generally consist of a clam shell arrangement of two buckets. The buckets may either close upon impact or be activated by use of a "messenger". Some dredges are heavy and may require use of a winch and crane assembly for sample retrieval. There are three major types of dredges: Peterson, Eckman and Ponar dredges.

The Peterson dredge is used when the bottom is rocky, in very deep water, or when the flow velocity is high. The Peterson dredge shall be lowered very slowly as it approaches bottom, because it can force out and miss lighter materials if allowed to drop freely.

The Eckman dredge has only limited usefulness. It performs well where bottom material is unusually soft, as when covered with organic sludge or light mud. It is unsuitable, however, for sandy, rocky, and hard bottoms and is too light for use in streams with high flow velocities.

The Ponar dredge is a Peterson dredge modified by the addition of side plates and a screen on the top of the sample compartment. The screen over the sample compartment permits water to pass through the sampler as it descends thus reducing the "shock wave". The Ponar dredge is easily operated by one person in the same fashion as the Peterson dredge. The Ponar dredge is one of the most effective samplers for general use on all types of substrates.

6.0 REFERENCES

American Public Health Association, 1980. Standard Methods for the Examination of Water and Wastewater, 15th Edition, APHA, Washington, D.C.

Feltz, H. R., 1980. Significance of Bottom Material Data in Evaluating Water Quality in Contaminants and Sediments. Ann Arbor, Michigan, Ann Arbor Science Publishers, Inc., V. 1, p. 271-287.

Kittrell, F. W., 1969. A Practical Guide to Water Quality Studies of Streams. U.S. Federal Water Pollution Control Administration, Washington, D.C., 135 p.

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U.S. EPA, 1980. Standard Operating Procedures and Quality Assurance Manual. Water Surveillance Branch, USEPA Surveillance and Analytical Division, Athens, Georgia.

U.S. Geological Survey, 1977. National Handbook of Recommended Methods for Water-Data Acquisition. Office of Water Data Coordination, USGS, Reston, Virginia.

ATTACHMENT A
SURFACE WATER SAMPLE LOG SHEET

Tetra Tech NUS, Inc. **SURFACE WATER SAMPLE LOG SHEET**

Page___ of ___

Project Site Name: ______________ Sample ID No.: ______________
Project No.: ______________ Sample Location: ______________
Sampled By: ______________
C.O.C. No.: ______________

[] Stream
[] Spring
[] Pond
[] Lake
[] Other: ______________
[] QA Sample Type: ______________

Type of Sample:
[] Low Concentration
[] High Concentration

SAMPLING DATA:

	Color	pH	S.C.	Temp.	Turbidity	DO	Salinity	Other
Date:	Visual	Standard	mS/cm	Degrees C	NTU	mg/l	%	NA
Time:								
Depth:								
Method:								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected

OBSERVATIONS / NOTES:	MAP:

Circle if Applicable:		Signature(s):
MS/MSD	Duplicate ID No.:	

ATTACHMENT B
SOIL & SEDIMENT SAMPLE LOG SHEET

Tetra Tech NUS, Inc.

SOIL & SEDIMENT SAMPLE LOG SHEET

Page___ of ___

Project Site Name: ____________
Project No.: ____________

[] Surface Soil
[] Subsurface Soil
[] Sediment
[] Other: ____________
[] QA Sample Type: ____________

Sample ID No.: ____________
Sample Location: ____________
Sampled By: ____________
C.O.C. No.: ____________

Type of Sample:
[] Low Concentration
[] High Concentration

GRAB SAMPLE DATA:

	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Date:			
Time:			
Method:			
Monitor Reading (ppm):			

COMPOSITE SAMPLE DATA:

	Time	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Date:				
Method:				
Monitor Readings (Range in ppm):				

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other

OBSERVATIONS / NOTES:

MAP:

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

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ATTACHMENTS

1.0 PURPOSE

This guideline is intended to describe procedures for performing in-situ hydraulic conductivity testing (slug testing) in boreholes and monitoring wells, and provide a short description of commonly used evaluation techniques for the data generated. Slug tests are used to provide data regarding the hydraulic properties of the formation tested. A variation of the slug test, called a constant-head test, is also briefly described.

2.0 SCOPE

Slug tests are short-term tests designed to provide approximate hydraulic conductivity values for the portion of a formation immediately surrounding the screened/open interval of a well or boring. These tests are much less accurate than pumping tests, as a much more localized area is involved. Therefore, a number of slug tests are typically performed and averaged to determine a representative hydraulic conductivity value for the formation tested. Performance of slug tests may be preferable to pumping tests in situations where handling of large volumes of contaminated water is a concern or when time/budget constraints preclude the more expensive and time-consuming setup and performance of a pumping test.

Constant-head tests also are used to determine hydraulic conductivity values and are similar to slug tests with regard to the quality of data obtained and time/cost considerations. A disadvantage of constant-head tests is that a significant volume of water may be added to high-permeability formations, potentially affecting short-term water quality.

3.0 GLOSSARY

Hydraulic Conductivity (K) - A quantitative measure of the ability of a porous material to transmit water, defined as the volume of water that will flow through a unit cross-sectional area of porous material per unit time under a head gradient of 1. Hydraulic conductivity is dependent upon properties of the medium and fluid. Common units of expression include centimeters per second (cm/sec), feet per day (ft/day), and gallons per day per foot^2 (gpd/ft^2).

Transmissivity (T) - A quantitative measure of the ability of an aquifer to transmit water. The product of the hydraulic conductivity times the saturated thickness.

Slug Test - A rising head or falling head test used to measure hydraulic conductivity. A slug test consists of instantaneously changing the water level within a well and measuring the rate of recovery of the water level to equilibrium conditions. Slug tests are performed by either withdrawing a slug of water (rising head test) or adding a slug of water (falling head test), then measuring recovery over time. A solid slug of known volume can be used to displace a volume of water, thereby simulating the addition or removal of water.

4.0 RESPONSIBILITIES

Project Hydrogeologist - The project hydrogeologist, in conjunction with the Project Manager, shall evaluate the type(s) and extent of hydraulic testing required for a given project during the planning process, and design the field program accordingly. The project hydrogeologist also shall ensure that field personnel have the necessary training and guidance to properly perform the tests, and shall oversee data reduction activities, including selecting the appropriate evaluation techniques and checking calculations for accuracy.

Field Geologist - The field geologist is responsible for performing the planned field tests as specified in the project planning documents, (or approved modifications thereto). The field geologist also generally assists in the data evaluation process. The field geologist shall be knowledgeable in the testing methodologies used and is responsible for obtaining the necessary support equipment required to perform the field tests. All applicable data regarding testing procedures, equipment used, well construction, and geologic/hydrogeologic conditions shall be recorded by the field geologist. The field geologist shall be familiar enough with testing procedures/requirements to be able to recommend changes in methodology, should unanticipated field conditions be encountered.

5.0 PROCEDURES

5.1 In-situ Hydraulic Conductivity Testing in Wells

Slug tests are commonly performed in completed wells. Prior to testing, the well shall be thoroughly developed and allowed to stabilize, in order to obtain accurate results. Once the water level within the well has stabilized at its static level, it shall be quickly raised or lowered and the rate of recovery measured.

One of the basic assumptions of slug testing is that the initial change in water level is instantaneous; therefore, an effort shall be made to minimize the time involved in raising or lowering the water level initially. Various methods can be used to induce instantaneous (or nearly instantaneous) changes in water level within the well. A rise in water levels can be induced by pouring water into the well. A solid slug of known volume, quickly lowered below the water level within the well, will displace an equivalent volume of water and raise the water level within the well. The slug can be left in place until the water level restabilizes at the static water level, then suddenly removed to create a drop in water level within the well. An advantage of using a solid cylinder of known volume (slug) to change the water level is that no water is removed or added to the monitoring well. This eliminates the need to dispose of contaminated water and/or add water to the system. A bailer or pump can be used to withdraw water from the well. If a pump is used, pumping shall not continue for more than several seconds so that a cone of depression is not created which would adversely impact testing results. The pump hose shall also be removed from the well during the recovery period, as data analysis techniques involve volume of recovery versus time, and leaving the hose within the well would distort the calculated testing results by altering the apparent volume of recovery. Falling head slug tests should only be performed in wells with fully submerged screens, while rising head slug tests can be performed in wells with either partially or fully submerged screens/open intervals.

Other methods that can be used to change water levels within a well include creating a vacuum or a high pressure environment within the well. The vacuum method will raise water levels within the well, while the pressure method will depress the water level in the well. These methods are particularly useful in highly permeable formations where other methods are ineffective in creating measurable changes in water levels. Both of these methods are limited to wells which have completely submerged screens.

Rate of recovery measurements shall be obtained from time zero (maximum change in water level) until water level recovery exceeds 90 percent of the initial change in water level. In low permeability formations, the test may be cut-off short of 90 percent recovery due to time constraints. Time intervals between water level readings will vary according to the rate of recovery of the well. For a moderately fast recovering well, water level readings at 0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.75, 1.0, 1.25, 1.5, 2.0, 2.5, 3.0, 4.0, . . . minutes may be required. With practice, readings at down to 0.05-minute (3 seconds) time intervals can be obtained with reasonable accuracy, using a pressure transducer and hand held readout. For wells which recover very fast, a pressure transducer and data logger may be required to obtain representative data. Time intervals between measurements can be extended for slow recovering wells. A typical schedule for measurements for a slow recovering well would be 0, 0.25, 0.5, 0.75, 1.0, 1.5, 2.0, 3.0, 4.0, 6.0, 8.0, 10.0, 15.0, 20.0, 30.0, . . . minutes from the beginning the test. Measurements shall be taken from the top of the well casing.

Water level measurements can be obtained using an electric water level indicator, popper, or pressure transducer. Steel tape coated with chalk or water sensitive paste although very accurate, is a slower method of obtaining water levels and is generally not recommended for use due to the frequency at which water level measurements need to be obtained during the performance of a slug test.

Time/recovery should be field-plotted on semilog graph paper to determine the data quality. The data set should plot along a sloped, straight line. If excessive data scatter is observed, the test should be rerun until acceptable results are obtained.

The following data shall be recorded when performing slug tests in wells or borings:

- Well/boring ID number
- Total depth of well/boring
- Screened/open interval depth and length
- Gravel pack interval depth and length
- Well stickup above ground surface
- Gravel pack radius
- Static water level
- Aquifer thickness
- Depth to confining layer
- Time/recovery data

A variation of the slug test, called a constant-head test, is a test in which water is added to the well at a measured rate sufficient to maintain the water level in the well at a constant height above the static water level. Once a stable elevated water level has been achieved, discharge (pumping) rate measurements are recorded in place of time/recovery data for approximately 10 to 20 minutes. The hydraulic conductivity is then calculated from this information. The constant-head test is generally not recommended for monitoring wells as large volumes of water may be introduced into the screened formation, potentially impacting later sampling events.

5.2 In-situ Hydraulic Conductivity Testing in Borings

Slug tests can be performed in borings while the boring is being advanced. This permits testing of formations at different depths throughout the drilling process. Boreholes to be tested shall be drilled using casing, so that discrete depths may be investigated. Various tests and testing methods are described below. The most appropriate test and testing method to be used in a situation varies and shall be selected after a careful evaluation of drilling, geologic, and general site conditions.

Rising head or falling head slug tests can be performed in saturated and unsaturated formations during drilling. There are two ways that the tests can be performed. One way entails setting the casing flush with the bottom of the boring when the desired testing depth has been reached. The hole is then cleaned out to remove loose materials, the drill bit and rods are carefully withdrawn from the boring, and a few feet of sand (of higher permeability than the surrounding formation) is added to the bottom of the boring. After the water level in the boring has stabilized (for saturated formations), the static water level is measured and recorded. The water level is then raised (falling head test) or lowered (rising head test) and the change in water level is measured at time intervals determined by the field hydrogeologist. Only falling head tests can be performed for depth intervals within the unsaturated (vadose) zone. As described for wells, time intervals for water level measurements will vary according to the formation's hydraulic conductivity. The faster the rate of recovery expected, the shorter the time intervals between measurements shall be. The rate of change of water level will be used to calculate hydraulic conductivity. The test is to be conducted until the water level again stabilizes, or for a minimum of 20 minutes. In low permeability formations, it is not always practical to run the test until the water level stabilizes, as it may take a long time to do so. The top of the casing shall be used as the reference point for all water level measurements.

The second method for conducting a slug test during drilling consists of placing a temporary well with a short screen into the cleaned-out boring, pulling the drilling casing back to expose the screen, allowing the formation to collapse around the screen (or placing a sand/gravel pack around the screen), and performing the appropriate hydraulic conductivity test in the well, as described for the first method. Again, the test shall be conducted until the water level stabilizes or for a minimum of 20 minutes. This method allows for testing a larger section of the formation and results in more reliable hydraulic conductivity estimates.

Constant-head tests may also be performed in borings. As described for monitoring wells, once a stable elevated level has been achieved, the discharge rate into the boring is measured for a period of time, usually 10 to 20 minutes, and the hydraulic conductivity is calculated from this. This method is the most accurate method depicted in this section, and shall be given preference over others if the materials are available to perform the test and the addition of water to the boring does not adversely impact project objectives. Once the test is over, additional information can be gathered by measuring the rate of the drop in water level in the boring (for saturated formations). A limitation of the constant-head test is that foreign water is introduced into the formation which must be removed from the well area by natural or artificial means, before a representative groundwater sample can be obtained.

Detailed descriptions regarding the performance of borehole hydraulic conductivity tests and subsequent data analysis techniques are provided in Ground Water Manual (1981).

5.3 Data Analysis

There are a number of data analysis methods available to reduce and evaluate slug testing data. The determination of which method is most appropriate shall be made based on the testing conditions (including physical setup of the well/boring tested, hydrogeologic conditions, and testing methodology) and the limitations of each test analysis method. Well construction details, aquifer type (confined or unconfined), and screened/open interval (fully or partially penetrating the aquifer) shall be taken into account in selecting an analysis method. Cooper, et al. (1967), and Papadapulos, et al. (1973) have developed test interpretation procedures for fully penetrating wells in confined aquifers. Hvorslev (1951) developed a relatively simple analytical procedure for point piezometers in an infinite isotropic medium. In Cedergren (1967), Hvorslev presents a number of analytical procedures which cover a wide variety of hydrogeologic conditions, testing procedures, and well/boring/piezometer configurations. Bouwer and Rice (1976) developed an analytical technique applicable to both unconfined and confined conditions, which factors in partial/full penetration and discusses well screen gravel pack considerations. The Ground Water Manual (1981) presents a number of testing and test analysis procedures for wells and borings open above or below the water table, and for both falling head and constant-head tests. The methods described above do not represent a complete listing of test analysis methods available, but are some of the more commonly used and accepted methods. Other methods can be used, at the discretion of the project hydrogeologist and in concurrence with the Project Manager and client.

One consideration to be noted during data analysis is the determination of the screened/open interval of a tested well. If a well with a fully submerged screen is installed in a relatively low permeability formation, and a gravel pack which is significantly more permeable is installed around the screen, the length of the gravel pack (if longer than the screened interval) should be used as the screened/open length, rather than the screen length itself. In situations where the formation permeability is judged to be comparable to the gravel pack permeability (within about an order of magnitude) this adjustment is not required.

All data analysis applications and calculations shall be reviewed by technical personnel thoroughly familiar with testing and test analysis procedures. Upon approval of the calculations and results, the calculation sheets shall be initialed and dated by the reviewer. Distribution copies shall be supplied to appropriate project personnel and the original copy stored in the project central file.

6.0 REFERENCES

Cedergren, H. R., 1967. Seepage, Drainage, and Flow Nets. John Wiley and Sons Inc., New York, pp. 78-76.

Cooper, H. H., Jr., J. D. Bredehoeft, and I. S. Papadopulos, 1967. Response of a Finite-Diameter Well to an Instantaneous Change of Water. Water Resources Research, V. 3, No. 1, pp. 263-269.

Hvorslev, M. J., 1951. Time Lag and Soil Permeability in Ground Water Observations. U.S. Army Corps of Engineers, Waterways Experiment Station, Washington, D.C., Bull. No. 36.

Papadopulos, I. S., J. D. Bredehoeft, and H. H. Cooper, 1973. On the Analysis of Slug Test Data. Water Resources Research, V. 9, No. 4, pp. 1087-1089.

Bouwer, H. and R. C. Rice, 1976. "A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells." Water Resources Research, 12:423-28.

United States Department of the Interior, 1981. Ground Water Manual. U.S. Government Printing Office, Denver, Colorado.

7.0 RECORDS

Field data shall be recorded on the data sheet included as Attachment A (or equivalent). 1 Any notes regarding testing procedures, problems encountered, and general observations not included on the data sheet shall be noted in the bound site logbook or field notebook. The boring log and well construction diagrams for each well/boring tested shall be used as references during testing and data analysis activities. Original data sheets shall be placed in the project file, along with the logbook/notebook.

1 If an automated data recorder is used, the data may be displayed using the printer output from the unit. Such printouts should be annoted to include the relevant data form, or attached to the form shown as Attachment A.

ATTACHMENT A
EXAMPLE HYDRAULIC CONDUCTIVITY TESTING DATA SHEET

HYDRAULIC CONDUCTIVITY TESTING DATA SHEET

PROJECT NAME: .... WELL/BORING NO.: ....

PROJECT NO.: .... GEOLOGIST: ....

WELL DIAMETER: .... SCREEN LENGTH/DEPTH: .... TEST NO.: ....

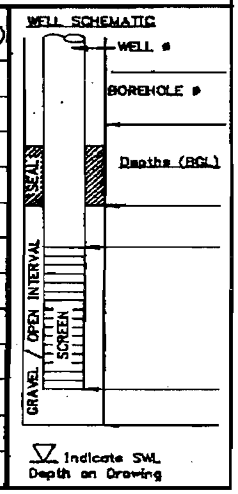
STATIC WATER LEVEL (Depth/Elevation): .... DATE: ....

TEST TYPE (Rising/Falling/Constant Head): .... CHECKED: ....

METHOD OF INDUCING WATER LEVEL CHANGE: .... PAGE ..... OF ....

REFERENCE PT. FOR WL MEAS. (Top of Casing, Transducer, etc.): ....

ELAPSED TIME (min. or sec.)	MEASURED WATER LEVEL (feet)	DRAWDOWN OR HEAD (ΔH) (feet)	ELAPSED TIME (min. or sec.)	MEASURED WATER LEVEL (feet)	DRAWDOWN OR HEAD (ΔH) (feet)



REMARKS:

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CALCS, SKETCH MAPS, ETC.:

TETRA TECH NUS, INC.	STANDARD OPERATING PROCEDURES	Number: SA-1.6	Page: 1 of 21
		Effective Date: 09/03	Revision: 1
		Applicability: Tetra Tech NUS, Inc.	
		Prepared: Earth Sciences Department	
Subject: NATURAL ATTENUATION PARAMETER COLLECTION		Approved: D. Senovich	

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1.0 PURPOSE

The purpose of this document is to provide general reference information regarding natural attenuation parameter and methodology selection, sample collection, and a general understanding of the sample results.

2.0 SCOPE

This document provides information on selection of appropriate groundwater natural attenuation parameters, selection of sampling methods for these parameters, techniques for onsite field analysis of select parameters, and some basic understanding of the field sample results. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling practices and techniques. To a limited extent, it shall also facilitate the understanding and interpretation of the sampling results. It addresses field procedures for collection of data at sites with organic groundwater contaminants (e.g., chlorinated and petroleum hydrocarbons) to the extent practical. The focus of this document is on natural attenuation, not enhanced bioremediation.

The techniques described shall be followed whenever applicable, noting that site-specific conditions, project-specific objectives, local, state, and federal guidelines may be used as a basis for modification of the procedures noted herein. The intent of this document is to supplement the local, state, and federal guidance documents and manufacturer's analytical methods referenced in Section 6.0. It is not intended for this document to supersede this guidance or information. Please note that natural attenuation is a relatively dynamic science with ongoing research in the science and engineering community. It is important that data collectors and interpreters use the most recent regulatory guidance, which may be updated on a periodic basis from that noted in Section 6.

3.0 GLOSSARY

Aerobe: Bacteria that use oxygen as an electron acceptor.
Anaerobe: Organisms that can use electron acceptors other than molecular oxygen to support their metabolism.
Anoxic groundwater: Groundwater that contains oxygen in concentrations less than about 0.5 mg/L. This term is synonymous with the term anaerobic.
Anthropogenic: Man-made.
Cometabolism: The process in which a compound is fortuitously degraded by an enzyme or cofactor produced during microbial metabolism of another compound.
Daughter product: A compound that results directly from the biotic or abiotic degradation of another. For example, *cis*-1,2-dichloroethene (*cis*-1,2-DCE) is a common daughter product of trichloroethene (TCE).
Diffusion: The process whereby molecules move from a region of higher concentration to a region of lower concentration as a result of Brownian motion.
Dispersion: The tendency for a solute to spread from the path that it would be expected to follow under advective transport.
Electron acceptor: A compound capable of accepting electrons during oxidation-reduction reactions. Microorganisms obtain energy by transferring electrons from an electron donor such as an organic compound (or sometimes a reduced inorganic compound such as sulfide) to an electron acceptor. Electron acceptors are compounds that are relatively oxidized and include oxygen, nitrate, iron(III), manganese(IV), sulfate, carbon dioxide, or in some cases chlorinated aliphatic hydrocarbons such as tetrachloroethene (PCE), TCE, DCE and vinyl chloride (VC).
Electron donor: A compound capable of supplying (giving up) electrons during oxidation-reduction reactions. Microorganisms obtain energy by transferring electrons from an electron donor such as an organic compound (or sometimes a reduced inorganic compound such as sulfide) to an

electron acceptor. Electron donors are compounds that are relatively reduced and include fuel hydrocarbons and native organic carbon.

Metabolic byproduct: A product of the reaction between an electron donor and an electron acceptor. Metabolic byproducts include volatile fatty acids, daughter products of chlorinated aliphatic hydrocarbons, methane, and chloride.

Oxic groundwater: Groundwater that contains oxygen in concentrations greater than about 0.5 mg/L.

Oxidation/reduction reaction: A chemical or biological reaction wherein an electron is transferred from an electron donor (donor is oxidized) to an electron acceptor (acceptor is reduced).

Predominant terminal electron-accepting process: The electron-accepting process (oxygen reduction, nitrate reduction, iron(III) reduction, etc.) that sequesters the majority of the electron flow in a given system.

Reductive dechlorination: Reduction of a chlorine-containing organic compound via the replacement of chlorine with hydrogen.

Respiration: The process of coupling the oxidation of organic compounds with the reduction of inorganic compounds such as oxygen, nitrate, iron(III), manganese(IV), and sulfate.

Seepage velocity: The average velocity of groundwater in a porous medium.

Substrate: A compound used by microorganisms to obtain energy for growth. The term can refer to either an electron acceptor or an electron donor.

4.0 RESPONSIBILITIES

Project Manager (PM) / Task Order Manager (TOM) - Responsible for ensuring that all field activities are conducted in accordance with this standard operating procedure (SOP).

Project Hydrogeologist or Geochemist - Responsible for selecting and detailing the specific groundwater sampling techniques, onsite water quality testing (type, frequency, and location), and equipment to be used, and providing detailed input in this regard to the project plan documents. The project hydrogeologist or geochemist is also responsible for properly briefing and overseeing the performance of the site sampling personnel.

Site Manager (SM) / Field Operations Leader (FOL) - Responsible for the onsite verification that all field activities are performed in compliance with approved SOPs or as otherwise directed by the approved project plan(s).

Project Geologist - is primarily responsible for the proper acquisition of the groundwater samples. He/she is also responsible for the actual analyses of onsite water quality samples, as well as instrument calibration, care, and maintenance. When appropriate, such responsibilities may be performed by other qualified personnel (e.g., field sampling technicians or site personnel).

5.0 PROCEDURES

5.1 General

Natural attenuation includes physical, chemical, and biochemical processes affecting the concentrations of dissolved contaminants in groundwater. These processes may include advection, dispersion, volatilization, dilution, sorption to aquifer solids, and/or precipitation or mineralization of compounds. Of greatest importance are those processes that lead to a reduction in contaminant mass (by degrading or destroying contaminants) such as biodegradation. These biochemical processes remove organic contaminants from the aquifer by destruction. Depending on the type of contaminant, particularly the organic contaminant (e.g., petroleum hydrocarbons or chlorinated organic solvents), the biochemical environment in the aquifer will vary. The biochemical environment within the aquifer influences and is influenced by the activities of aquifer microbiota. Specific types of microbiota, working singly or in complex consortia, may use organic contaminants as part of their normal cell functions. Natural attenuation monitoring is designed to measure indicators of the biochemical environment within the aquifer and, with direct and indirect lines of evidence and associated chemical concentration data, evaluate the likely fate (i.e., transformation, destruction, dilution, attenuation, etc.) of organic contaminants.

5.2 Planning for Natural Attenuation Sampling

The first step in preparing a natural attenuation investigation is to develop a site-specific conceptual model. The first step in development of this model is the analysis and review of available site-specific characterization data. The development and refinement of this model should be supplemented with additional data as needed. The data should include but is not limited to:

- Geologic and hydrogeologic information in three dimensions
- Nature, extent, and magnitude of contamination
- Location and presence of potential receptors to contamination

Lines of Evidence

Several lines of evidence are used to determine whether natural attenuation is working. The most compelling, primary evidence is decreasing groundwater contaminant concentrations over time. Decreasing concentration trends can be demonstrated in several ways including:

- Isoconcentration maps of the dissolved plume over time wherein the extent of the plume is either stable or decreasing.
- Time series plots of contaminant concentrations within a well illustrating a clear downward trend.
- Contaminant concentration profiles in a series of monitoring wells along a groundwater flow path illustrating decreasing concentrations beyond that attributable to dilution and dispersion.

Secondary, or supporting, lines of evidence include:

- Analytical data showing production and subsequent destruction of primary contaminant breakdown products.
- Geochemical data indicating that the biochemical environment is favorable for the appropriate microbiota.
- Geochemical data that indicate the aquifer microbiota are active.

Monitoring Well Location and Sampling Frequency

The number and locations of wells required to monitor natural attenuation will depend on the physical setting at each location. One possible array of monitoring wells is illustrated in Attachment A. In this scenario, one well is used to monitor conditions upgradient of the source, one well is located in the source area, and several wells are used to define and monitor the downgradient and lateral extent of the dissolved plume. At a minimum, there should be at least one upgradient well (ideally with no contamination present), one well in the source area, one well downgradient from the source area in the dissolved plume, and one downgradient well where contaminant concentrations are below regulatory criteria. Note that the number and locations of monitoring wells will vary depending on the site complexity and site objectives.

Sampling frequency will be dictated by the ultimate use of the data and site-specific characteristics. Contaminant concentrations may be used to define statistically meaningful trends in contaminant concentrations. The sampling frequency may be defined by the hydrogeologic and/or geochemical conditions as well as the proposed statistical method for data analysis. For example, groundwater flow and contaminant characteristics (e.g., seepage velocity and contaminant loading) may dictate the sample frequency. Regardless of the factors, sampling frequency and duration will need to establish the range of natural chemical variability within the aquifer. After a sufficient amount of data has been collected and the geochemical conditions are understood, the frequency of sampling may be reduced. See Section 5.4 for additional information on sample collection and frequency.

5.3 Selection of Natural Attenuation Parameters

Natural attenuation via biodegradation depends on the nature of the organic contaminants and the oxidation-reduction (redox) environment within the aquifer. Simply stated, if the contaminants are fuels, biodegradation will be most effective if the redox conditions are aerobic or oxidizing. If the contaminants are chlorinated solvents, the biodegradation will be most effective (in the source and near source areas) if redox conditions in the aquifer are anaerobic or reducing.

Several parameters are needed to evaluate whether natural attenuation is taking place and, if so, the rate at which it may be occurring. The primary parameter providing direct evidence of natural attenuation is the aqueous concentrations of parent and daughter volatile organic compounds. More specifically, a decrease in percent products, an increase in daughter products, evidence that the plume is stable or shrinking in size, and overall decline in contaminant concentrations is direct evidence of natural attenuation. Natural attenuation or geochemical parameters that provide information about the redox conditions in the aquifer include:

- Dissolved oxygen
- Nitrate/nitrite
- Dissolved manganese
- Iron
- Sulfate/sulfide
- Methane
- Oxidation-reduction potential (ORP)

Secondary parameters that indicate biological activity in the aquifer and thereby support the natural attenuation evaluation include:

- Dissolved hydrogen
- Alkalinity
- Dissolved carbon dioxide

The concentrations of natural attenuation parameters are used to define the aquifer redox conditions. It is important to record and document the presence or absence (i.e., measurable or not measurable concentration) of certain natural attenuation parameters. The presence or absence of a certain substance may be sufficient to indicate the redox condition within the aquifer. By reference to Attachment B, which illustrates the typical sequence of biologically mediated redox reactions in natural systems, it is apparent that, for example, sulfate reduction (producing dissolved sulfide in groundwater) does not operate in an aerobic environment. Therefore, measurable sulfide should not be present if there is also dissolved oxygen at concentrations indicating an aerobic environment. Attachment B also illustrates the redox potential (measured in millivolts) associated with the redox reactions. ORP readings, also in millivolts, measured during well purging, may be compared with the range of values in Attachment B but with caution. Redox potentials measured with a platinum electrode in natural water samples may be misleading, especially when biologically mediated reactions are important, because many of the critical reactions in Attachment B do not generate a response in the electrode. Dissolved hydrogen concentration ranges associated with important redox reactions are also indicated in Attachment B. Because dissolved hydrogen is actually used by microbiota during redox reactions, its concentration may provide an additional indicator of the overall redox condition in the aquifer.

Attachments C and D tabulate the natural attenuation parameters for chlorinated volatile organic compound and petroleum hydrocarbon plumes, respectively. The parameters listed in these tables are organized in order of importance. Parameters selected for analysis shall be determined based on site conditions, project-specific plans, and/or other criteria established for the project. Based on these criteria, it is possible that all of the parameters may be selected.

5.4 Selection of Natural Attenuation Analytical Methods and Procedures

There are many analytical methods available to measure concentrations of the natural attenuation parameters discussed in the previous sections. Attachment E summarizes the sample methodologies, sampling equipment needed, sample volume, container, preservation, and holding time requirements. This table also summarizes the detection limits and the detection ranges for each method. A number of factors should be considered when selecting the appropriate sample analytical methodology including the required parameters, appropriate detection ranges for each compound, cost, and ease of use in the field. For example, when determining the correct methodology for measuring concentrations of total sulfide, the metabolic byproduct of sulfate reducing conditions, it is important to analyze for each of the forms of sulfide (H_2S, S^{-2}, and HS^{-}). Also, when the detection limit of the selected method is exceeded, another method may be considered, or the sampler may be able to dilute the sample (per manufacturer's instructions) to quantify it within the detected range. In terms of cost, some parameters are very time consuming when performed in the field. Without sacrificing sample integrity it may be more appropriate to select a methodology performed in a fixed-base laboratory. Finally, in terms of ease of use, certain field methods are generally easier compared to other methods. Using simpler methods may result in better quality sample results and increased sample repeatability without sacrificing sample integrity. For example, in some cases CHEMetrics Titret® Titration Ampule kits may be a good alternative to other hand digital titration methods.

The sample technicians should be aware that based on geochemical conditions recorded in the field, certain geochemical parameters may not have positive detections. For example, if dissolved oxygen concentrations indicate aerobic conditions then it is unlikely that dissolved hydrogen is present (see Section 5.10 for additional information). Another example is alkalinity. If the pH of the groundwater sample is less than 4.5, then it is unlikely that alkalinity will be measurable. Despite the potential for non-detect results, in cases such as those described above, all parameters should be collected in the field based upon project plans. The value in collecting the parameters in the future shall be determined by the project hydrogeologist and/or geochemist in accordance with the projects planning documents data quality objectives (DQO) and the items discussed in Section 5.2.

5.5 Procedures for Sample Collection

Groundwater sample collection for natural attenuation sampling should be performed using low flow purging and sampling techniques. These techniques are described in detail in SOP SA-1.1. Low flow purging and sampling procedures should be used to ensure the collection of a sample that is "representative" of the water present in the aquifer formation. Minimizing stress on the aquifer formation during low flow purging and sample collection ensures that there are minimal alternations to the water chemistry of the sample. The criteria used in the purging process should include minimization of drawdown in the well, stabilization of applicable indicator parameters, and evacuation of a sufficient amount of purge volume in accordance with SOP SA-1.1, project plans, and/or applicable regulatory guidance.

Groundwater purging and sampling for natural attenuation should be performed using submersible pumps (e.g., bladder pumps) in accordance with SOP SA-1.1. However, in accordance with project plans and applicable regulatory guidance, peristaltic pumps may also be used for this purpose. Limitations of and factors associated with using these devices should be considered (see SOP SA-1.1 for more information). As a result of difficulties in collecting "representative" groundwater samples, bailers should not be used for the collection of natural attenuation samples.

It is critical that disturbance and aeration of samples monitored and collected at the well head are minimized. As a result, a flow-through sampling cell and a direct reading meter shall be used for the measurement of well stabilization indicator parameters (e.g., pH, conductivity, temperature, dissolved oxygen, turbidity, and ORP) at the well head. The pump effluent tubing should be placed at the bottom of the flow-through cell allowing effluent water from the cell to discharge at the top of the meter (above the detector probes) to minimize the agitation of water in the cell.

Documentation of the purging process shall be recorded during and at the completion of purging as discussed in Section 5.8. Immediately following the purging process and before sampling, all applicable indicator parameters must be measured and recorded on the appropriate sample log sheets as discussed in Section 5.8.

After all of the purging requirements have been met, groundwater sampling and natural attenuation data collection can begin. Monitoring wells will be sampled using the same pump and tubing used during well purging.

5.6 Procedures for Field Sample Analysis

Each of the field and fixed-base laboratory sample parameters requires different sampling procedures and holding times. Attachment E presents parameter-specific requirements for sampling, analysis, and storage of all of the parameters and methods sampled as part of natural attenuation analysis.

Due to parameter procedure and holding times, it is important to consider the sequence of sample collection and analysis. Generally speaking, with the exception of volatile organic compounds, field parameters shall be analyzed first followed by fixed-base laboratory sample collection. All samples will be collected in a sequence and manner that minimizes volatilization, oxidation, and/or chemical transformation of compounds. As a result, the following sample and analysis order should be followed:

1. Volatile organic compounds
2. Dissolved oxygen
3. Alkalinity
4. Dissolved carbon dioxide
5. Dissolved ferrous iron
6. Dissolved sulfide (hydrogen sulfide and sulfide)
7. Dissolved hydrogen, methane, ethene, and ethane
8. Nitrate / Nitrite
9. Dissolved manganese
10. Semivolatile organic compounds
11. Other dissolved metals
12. Total metals
13. All other constituents

Field-analyzed parameters should be collected and immediately analyzed directly from the pump effluent per the requirements on Attachment E and manufacturer's recommendations. Care should be taken to minimize any unnecessary disturbance, aeration, or agitation of the sample prior to analysis. It is not acceptable to collect and store samples that are to be analyzed immediately at the well head in a temporary holding container (e.g., open topped pitcher) to be analyzed at a later time.

The manufacturer's procedure manual for each of the field-based analyses shall be maintained in the field during the entire sampling program. The procedures give a detailed explanation of how to perform each particular method and include information on sampling, storage, accuracy checks, interferences, reagents, and apparatus needed to perform each analysis.

5.7 Procedures for Quality Assurance and Quality Control Field Sample Analysis

Accuracy and precision checks shall be performed to check the performance of the reagents, apparatus, and field analytical procedures per the manufacturer's recommendations. The accuracy checks should include the use of standard solutions (i.e., standard addition), as appropriate. The manufacturer's field test kit manual provides details on how to perform each of the accuracy checks for each parameter where applicable. Refer to Section 6.0 for manufacturer contact information.

Precision checks must include the performance of duplicate analysis. When using a colorimeter, precision checks may also include reagent blank corrections and standard curve adjustments as recommended by the manufacturer. Field duplicate results shall be performed and evaluated for relative percent difference (RPD) at a rate of 1 per 10 samples or as determined by the project plans. The RPD can be calculated as follows:

$$RPD = \left| \frac{\text{First result - Second result}}{\text{Mean arithmetic (average) of first and second result}} \right| \times 100$$

If the RPD exceeds 50 percent, it is required that the test be performed again to verify the result. The duplicate results shall be documented in the 'Notes' section for that specific parameter on the appropriate sample logsheet (see Section 5.8).

If a colorimeter (e.g., HACH DR-890 or equivalent) is used for parameter analysis, an instrument performance verification test using absorbance standards may also be performed to ensure the meter is providing accurate measurements.

The following table lists examples of the types and frequencies of accuracy checks required for each parameter. Refer to the manufacturer's instructions for information regarding other analyses.

Parameter	Method	Standard Solution	Field Duplicate	Reagent Blank Correction
Alkalinity	CHEMetrics K-9810, -15, -20	None	1 per 10	None
Carbon dioxide	CHEMetrics K-1910, -20, -25	None	1 per 10	None
Dissolved oxygen	CHEMetrics K-7501, -12	None	1 per 10	None
Ferrous iron	HACH DR-890	None	1 per 10	None
Nitrite	HACH DR-890	1 per round	1 per 10	1 per lot
Nitrate	HACH DR-890	1 per round	1 per 10	1 per lot
Sulfide	HACH DR-890	None	1 per 10	None
Hydrogen sulfide	HACH HS-C	None	1 per 10	None

Prior to analysis, the expiration dates of reagents shall be checked. If the reagents have exceeded their expiration date or shelf life, the reagents shall be replaced. If deviations from the applicable analytical procedure are identified, the deviations shall be corrected and the associated samples re-analyzed. If problems are identified with the reagents, apparatus, or procedures, data interferences may be present. Interferences may also be due to other factors (e.g., pH, presence or concentration of other ions, turbidity, temperature, etc.) that may interfere with the sample result. The manufacturer's procedures (e.g., Hach, 1999) should be reviewed prior to analysis to avoid or minimize such interferences. Associated problems or suspected interferences shall be documented in the 'Notes' section of the sample logsheet. Often, interferences cannot be avoided. In these cases, the sampler should be aware of these potential interferences and document them properly.

5.8 Documentation Procedures for Field Sample Analysis

Field results shall be properly documented in the field as noted in SOP SA-6.3. The sample log sheet titled "Field Analytical Log Sheet, Geochemical Parameters" shall be prepared for each sample collected and analyzed in the field. A copy of this form can be found as Attachment F of this SOP. Other field log sheets (e.g., low flow purge log sheet, groundwater sample logsheet, etc.) shall also be completed in accordance with SOP SA-6.3.

Specific information shall also be recorded in the project logbook. This information shall include, but is not limited to, the test kit name and model number, lot number and expiration date of the test kit and reagents used, serial number of the instrument (e.g., colorimeter) used for the analysis, and results of the quality assurance and quality control field sample analysis. Because environmental conditions and changes in those conditions may affect the field analytical results, it is important to document the site conditions (weather, temperature, etc.) at the time of sampling in the logbook in accordance with SOP SA-6.3.

5.9 Waste Handling and Disposal

Several of the test kits listed in Attachment E require the use of chemicals and materials that must be properly handled and disposed of in a proper and responsible manner. Refer to specific manufacturer's guidance for handling and disposal practices. See also Section 6.0 for more detailed and complete information. Handling and disposal of these items should be conducted in accordance with all local, state, and federal guidelines.

5.10 Understanding Field Sample Analytical Results

Natural attenuation data interpretation is complicated by the complex inter-relationships of various parameters. The complexity reflects the myriad of biochemical processes. Real-time evaluation of field analytical data can be misleading because a full interpretation often requires combining the field analytical results with fixed-base laboratory results. Regardless, some simple observations and data interpretations in the field may provide insights about the monitoring system or early warnings about sample collection and handling problems.

Data collected from the designated upgradient monitoring well is the baseline from which other interpretations are made. Field analytical data will indicate that the upgradient environment is either oxidizing or reducing. The redox condition within the upgradient area of the aquifer may be natural or impacted by other contaminant source areas (see Section 5.2 for upgradient well selection). Regardless, the redox condition of the upgradient groundwater will influence the source area. Changes in field analytical results from the upgradient well to the source area well will be reflected in samples from monitoring wells further downgradient.

The general characteristics of the two redox environments are summarized in the following table.

Aerobic/Oxidizing	Anaerobic/Reducing
• Measurable dissolved oxygen (>1 to 2 ppm)	• No measurable dissolved oxygen (<1 ppm)
• Measurable nitrate	• No measurable nitrate
• No measurable dissolved manganese	• Measurable dissolved manganese
• No measurable dissolved ferrous iron	• Measurable dissolved ferrous iron
• Measurable dissolved sulfate	• No measurable dissolved sulfate
• No measurable dissolved sulfide	• Measurable dissolved sulfide
• No measurable dissolved methane	• Measurable dissolved methane
• No measurable dissolved hydrogen	• Measurable dissolved hydrogen

Transitional environments between these two extremes may have intermediate characteristics and are actually quite common. Because reactions are mediated by biological systems, equilibrium (the basis for the figure in Attachment B) conditions within the aquifer should not be expected. For example, sulfate reduction environments may occur in close proximity to methanogenic environments, and this natural attenuation data may be difficult to interpret. Carefully collected and analyzed field measurements and sample collections for fixed-base laboratory analyses are designed to characterize the aquifer environment along the continuum between strongly aerobic and strongly anaerobic. Because the land surface environment is generally more oxidizing than any groundwater environment, sample handling at the point of collection and analysis is extremely important in preserving the chemical integrity of the groundwater sample.

6.0 REFERENCES

American Society for Testing and Materials (ASTM), 1998. Standard Guide for Remediation of Ground Water by Natural Attenuation at Petroleum Release Sites, Designation: E1943-98, West Conshohocken, Pennsylvania.

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USEPA (United States Environmental Protection Agency), 1998. Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water, EPA/600/R-98/128, Office of Research and Development, Washington, D.C.

Hach Company, 1999. DR-890 Colorimeter Procedures Manual, Product Number 48470-22, Loveland Colorado.

Hach Company, 1999. Digital Titrator (manual), Model Number 16900, Catalog Number 16900-08. Loveland, Colorado.

Hach Company, 2002, http://www.hach.com/.

USEPA, 1997. Draft EPA Region 4 Suggested Practices for Evaluation of a Site for Natural Attenuation (Biological Degradation) of Chlorinated Solvents; Version 3.0. November.

USEPA, 1999. Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites, USEPA OSWER Directive 9200.4-17P, April 21, 1999

ATTACHMENT A

HYPOTHETICAL LONG-TERM MONITORING STRATEGY

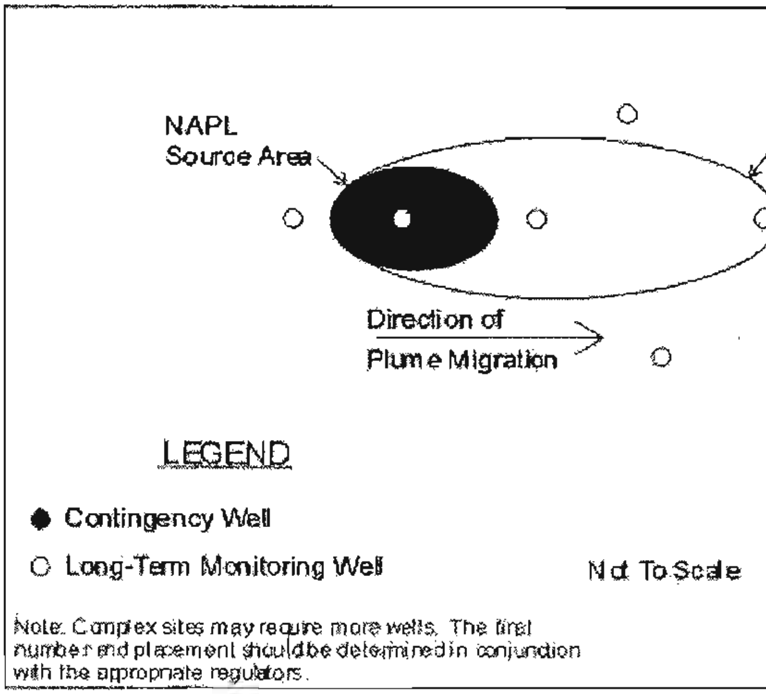
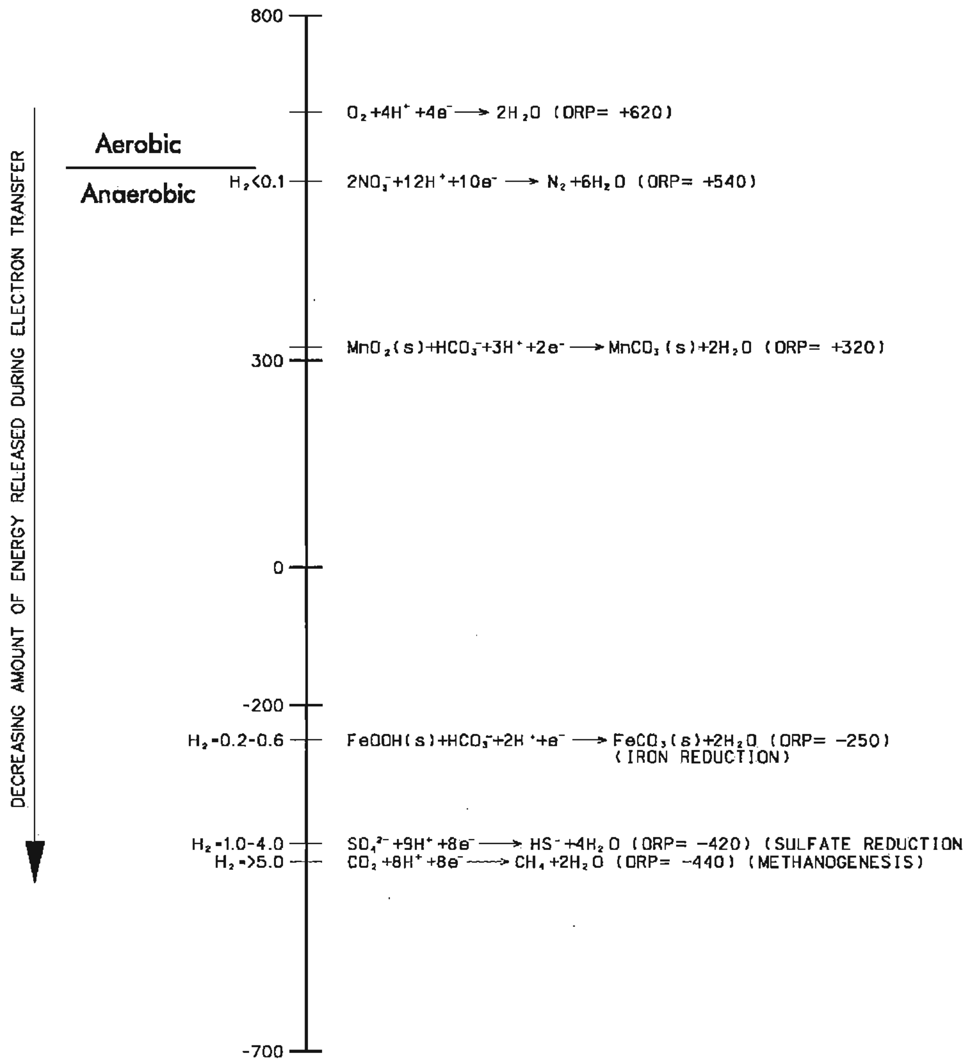


Figure 6.1
Hypothetical Long-Term Monitoring Strategy - Non-Discharging Plume

Taken from: Department of the Navy, 1998, Technical Guidelines for Evaluating Monitored Natural Attenuation of Petroleum Hydrocarbons and Chlorinated Solvents in Ground Water at Naval and Marine Corps Facilities, Prepared by Todd Weidemeier and Francis Chappelle.

ATTACHMENT B

REDOX POTENTIALS FOR VARIOUS ELECTRON ACCEPTORS



Dissolved hydrogen (H_2) concentration in nanomoles per liter (nM)
Oxidation Reduction Potential (ORP vs Ag/AgCl) in millivolts @ pH=7, T=25°c

FIGURE B
REDOX POTENTIALS
FOR VARIOUS ELECTRON ACCEPTORS

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ATTACHMENT C

NATURAL ATTENUATION PARAMETERS FOR CHLORINATED VOLATILE ORGANIC COMPOUND PLUMES SCREENING PROCESS SUMMARY FOR REDUCTIVE (ANAEROBIC) DECHLORINATION

Potential Electron Donors	Electron Acceptors:		Reduced Species:		Related Dechlorination Pathway:
	Dissolved Oxygen	⇒	Carbon Dioxide (CO_2)	~	DCE → VC → CO_2
Native total organic carbon (TOC)	Manganese (Mn^{4+})	⇒	Manganese (Mn^{2+})	~	DCE → VC
Anthropogenic carbon (e.g., leachate)	Nitrate (NO_3)	⇒	Nitrite (NO_2)	~	DCE → VC
Fuel hydrocarbons (e.g., BTEX)	Ferric Iron (Fe^{3+})	⇒	Ferrous Iron (Fe^{2+})	~	DCE → VC → CO_2
Lightly chlorinated solvents (DCE/VC)	Sulfate (SO_4)	⇒	Sulfide (S^{2-}, HS^-, H_2S)	~	TCE → DCE → VC → Ethene
	Carbon Dioxide (CO_2)	⇒	Methane (CH_4)	~	PCE → TCE → DCE → VC → Ethene

Geochemical Parameter List:

Parameter	Field or Lab	Rationale	Importance
Volatile organic compounds	L	Source products; daughter products; electron donors (e.g., benzene, toluene, ethylbenzene, and xylene; BTEX)	1
Dissolved oxygen	F	Primary electron acceptor (respiration); an/aerobic indicator	1
Nitrate (and nitrite), dissolved	F or L	Anaerobic electron acceptor (product of nitrate reduction)	1
Manganese, dissolved	F or L	Anaerobic electron acceptor	1
Ferrous Iron (Fe^{2+})	F	Product of iron reduction	1
Sulfate [and sulfide (S^{-2})]	F or L	Common anaerobic electron acceptor (product of sulfate reduction)	1
Sulfide (H_2S)	F	Common product of sulfate reduction	1
Methane, ethane, ethene	L	Product of methanogenesis; daughter products of reductive dechlorination	1
Chloride	L	Ultimate daughter product of reductive dechlorination	1
TOC - upgradient groundwater	L	Electron donor	1
ORP, pH, specific conductance, temperature, turbidity	F	General water quality determination	1
Carbon dioxide (CO_2)	F	Anaerobic electron acceptor (methanogenesis); biotic respiration indicator	2
Alkalinity/DIC	F	Buffering capacity; biotic respiration indicator	2
Hydrogen, dissolved	L	Fingerprint for characterizing electron acceptor pathway - indicator of what redox is occurring	2
TOC - upgradient soil	L	Input to analytical NA models; quantifies soil-water distribution coefficient and retardation factor	2
Volatile fatty acids	L	Determination of anthropogenic carbon used as an electron donor	3

Importance: 1=Most important; 3=Least important (depending on DQOs, all may be recommended).
See Attachment E for details regarding analytical methods.

ATTACHMENT D

NATURAL ATTENUATION PARAMETERS FOR PETROLEUM HYDROCARBON PLUMES SCREENING PROCESS SUMMARY FOR OXIDATIVE (AEROBIC) DEGRADATION

Parameter	Field or Lab	Rationale	Importance
Volatile organic compounds	L	Source products; daughter products; electron donors (BTEX)	1
Dissolved oxygen	F	Primary electron acceptor (respiration); an/aerobic indicator	1
Nitrate (and nitrite), dissolved	F or L	Anaerobic electron acceptor (and product of nitrate reduction)	1
Manganese, dissolved	F or L	Anaerobic electron acceptor	1
Ferrous Iron (Fe^{2+})	F	Product of iron reduction	1
Sulfate [and Sulfide (S^{-2})]	F or L	Common anaerobic electron acceptor (product of sulfate reduction)	1
Sulfide (H_2S)	F	Common product of sulfate reduction	1
TOC - upgradient groundwater	L	Electron donor	1
ORP, pH, specific conductance temperature, turbidity	F	General water quality determination	1
Dissolved methane (CH_4)	L	Product of methanogenesis	1
Anions: chloride (Cl), nitrate (NO_3), nitrite (NO_2), phosphate (PO_4), sulfate (SO_4)	L		1
TOC - Upgradient soil	L	Input to analytical NA models; quantifies soil-water distribution coefficient and retardation factor	2
Biological oxygen demand (BOD)	L	Understanding of aquifer oxygen demand	3
Chemical oxygen demand (COD)	L	Understanding of aquifer oxygen demand	3

Importance: 1=Most important; 3=Least important (depending on DQOs, all may be recommended).

See Attachment E for details regarding analytical methods.

ATTACHMENT E
GEOCHEMICAL SAMPLING PARAMETERS - METHODS, EQUIPMENT, VOLUMES, CONTAINERS, PRESERVATION, HOLDING TIMES, AND DETECTION RANGES
PAGE 1 OF 4

Parameter	Method / Reference	Equipment / Method Chemistry	Sample Volume, Container, Preservation, & Holding Time	Range (mg/L)	Precision (mg/L)	Estimated Detection Limit (mg/L)
Alkalinity	CHEMetrics K-9810, K-9815, K-9820 -ASTM D 1067-92 -EPA 310.1	Titret® Titration Ampules / Hydrochloric Acid, Phenolphthalein	Field. Follow test kit instructions. Avoid agitation and analyze at well head to determine total alkalinity. Filter if turbid (>10 NTU).	10-100 (K-9810) 50-500 (K-9815) 100-1000 (K-9820)	N/A	10 50 100-
Alkalinity	Fixed-base lab -EPA 310.1	N/A	100 to 250 mL in glass or plastic container. Cool to 4°C. Analyze within 14 days. Filter if turbid.	N/A	N/A	N/A
Alkalinity / Dissolved Inorganic Carbon	HACH AL-DT -HACH 8203 -SM 2320 / SM 403	Digital Titration / Hydrochloric Acid, Phenolphthalein (P) and Total (M)	Field. Follow test kit instructions. Avoid agitation and analyze at well head to determine carbonate, bicarbonate, and hydroxide ions. Filter if turbid as recommended by manufacture. May use a pH meter for colored samples.	10-4000	N/A	10
Arsenic	Fixed-base lab -SW-6010 B	N/A	1 liter glass or polyethylene container, HNO_3 to pH $\leq$ 2, 6 months.	N/A	N/A	N/A
Biochemical Oxygen Demand	Fixed-base lab -EPA 410.1	N/A	2 liter HDPE. Cool to 4°C. Analyze within 48 hours.	N/A	N/A	N/A
Carbon Dioxide, dissolved	CHEMetrics K-1910, K-1920, K-1925 -ASTM D 513.82 -SM 4500-CO_2-C	Titret® Titration Ampules / Sodium Hydroxide, Phenolphthalein	Field. Follow test kit instructions. Avoid agitation and analyze at well head.	10-100 (K-1910) 100-1000 (K-1920) 250-2500 (K-1925)	N/A	10 100 250
Carbon Dioxide, dissolved	Fixed-base lab - VOA water sample (Vaportech)	GC-ECD/RGD/FID Detector	40 mL in VOA vial. 2 to 3 vials by (Vaportech).	N/A	N/A	N/A
Carbon Dioxide, dissolved	Fixed-base lab -Microseeps gas stripping cell	GC-ECD/RGD/FID Detector	Field bubble-strip sampling required. Ship in glass septum vial (Microseeps only).	N/A	N/A	N/A
Carbon Dioxide, dissolved	HACH CA-DT -HACH 8205 -Mod. SM 406	Digital Titration / Sodium Hydroxide, Phenolphthalein	Field. Follow test kit instructions. Do not aerate or agitate. Analyze at well head.	10-1000	N/A	10
Chemical Oxygen Demand	Fixed-base lab -EPA 410.1	N/A	125 mL HDPE. H_2SO_4 to pH <2.0. Cool to 4°C. Analyze within 28 days.	N/A	N/A	N/A
Chloride (Cl)	Fixed-base lab -EPA 300	N/A	100 to 250 mL in glass or plastic container. Cool to 4°C. Analyze within 28 days.	N/A	N/A	N/A
Chlorine - Total (Cl_2)	HACH DR-850 -HACH 8167 -SM 4500-Cl	Colorimeter / DPD Method	Field. Follow test kit instructions.	0.02-2.00	$\pm$ 0.01 mg/L with a 1.00 mg/L chlorine solution.	1
Conductance, Specific	Field Meter -SW-9050 A	Direct Reading Meter	100 to 250 mL in glass or plastic container. Analyze immediately.	N/A	N/A	N/A
Ethane, dissolved	Fixed-base lab -VOA water sample, Vaportech -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	40 mL in VOA vial. 2 tol 3 vials by (Vaportech).	N/A	N/A	N/A
Ethane, dissolved	Fixed-base lab -Microseeps gas stripping cell -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	Field bubble-strip sampling required. Ship in glass septum vial (Microseeps only).	N/A	N/A	N/A

ATTACHMENT E

GEOCHEMICAL SAMPLING PARAMETERS - METHODS, EQUIPMENT, VOLUME, CONTAINER, PRESERVATION, HOLDING TIME, AND DETECTION RANGES
PAGE 2 OF 4

Parameter	Method / Reference	Equipment / Method Chemistry	Sample Volume, Container, Preservation, & Holding Time	Range (mg/L)	Precision (mg/L)	Estimated Detection Limit (mg/L)
Ethene, dissolved	Fixed-base lab -VOA water sample, Vaportech -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	40 mL in VOA vial. 2 to 3 vials by (Vaportech).	N/A	N/A	N/A
Ethene, dissolved	Fixed-base lab -Microseeps gas stripping cell -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	Field bubble-strip sampling required. Ship in glass septum vial (Microseeps only).	N/A	N/A	N/A
Fraction Organic Carbon (foc) -Soil Upgradient Saturated Soil	Fixed-base lab -Walk-Black -SW-846 9060	N/A	200 gram glass jar. Cool to 4°C. Analyze within 14 days.	N/A	N/A	N/A
Hydrogen, dissolved	Fixed-base lab -Microseeps or Vapor Tech gas stripping cell -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	Field bubble-strip sampling required. Ship in glass septum vial.	N/A	N/A	N/A
Iron, ferrous (Fe^{+2})	HACH DR-850 -HACH 8146 -Mod. SM 315 B	Colorimeter 1, 10 Phenanthrolein	Field. Follow test kit instructions. Analyze immediately at well head. Filter if turbid (>10 NTU) as recommended by the manufacture.	0-3.00	±0.017 mg/L with a 2.00 mg/L Fe^{2+} solution.	0.03
Iron, ferrous (Fe^{+2})	HACH IR-18C -Mod. SM 315 B	Color Disc 1, 10 Phenanthrolein	Field. Follow test kit instructions. Analyze immediately at well head. Filter if turbid (>10 NTU) as recommended by the manufacture.	0-10	N/A	0.2
Iron, total dissolved (Filtered)	Fixed-base lab -SW-846 6010B	N/A	250 mL in plastic container. Field filter to 0.45 µ. HCl to pH <2. Cool to 4°C. Analyze within 6 months.	N/A	N/A	N/A
Manganese (Mn^{+2})	HACH DR-850 -HACH 8034 -CFR 44(116) 34193	Colorimeter / Cold Periodate Oxidation	Field. Follow test kit instructions. Avoid agitation and analyze at well head. Filter if turbid as recommended by the manufacture.	0-20.0	± 0.18 mg/L with a 10.00 mg/L Mn solution.	0.12
Manganese (Mn^{+2})	HACH MN-5 -Mod. SM 319 B -CFR 44(116) 34193	Color Disc / Cold Periodate Oxidation	Field. Follow test kit instructions. Avoid agitation and analyze at well head. Filter if turbid as recommended by the manufacture.	0-3	N/A	0.1
Manganese, total dissolved (Filtered)	Fixed-base lab -SW-846 6010B	N/A	250 mL in plastic container. Field filter to 0.45 µ. HCl to pH <2. Cool to 4°C. Analyze within 6 months.	N/A	N/A	N/A
Methane, dissolved	Fixed-base lab -VOA water sample, Vaportech -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	40 mL in VOA vial. 2 to 3 vials by (Vaportech).	N/A	N/A	N/A
Methane, dissolved	Fixed-base lab -Microseeps gas stripping cell -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	Field bubble-strip sampling required. Ship in glass septum vial (Microseeps only).	N/A	N/A	N/A
Nitrate (NO_3^-)	Fixed-base lab -EPA 300	N/A	250 mL plastic container. Cool to 4°C. Analyze within 48 hours.	N/A	N/A	N/A
Nitrate (NO_3^-)	HACH DR-850 -HACH 8192 -Mod. EPA 353.2	Colorimeter / Cadmium Reduction	Field. Follow test kit instructions. Avoid agitation and analyze at well head. Pretreatment required if nitrite is present.	0-0.50	± 0.03 mg/L with a 0.25 mg/L of nitrate nitrogen (NO_3^- N) solution.	0.01
Nitrite (NO_2^-)	Fixed-base lab -EPA 300	N/A	250 mL plastic container. Cool to 4°C. Analyze within 48 hours. Filter if turbid as recommended by the manufacture.	N/A	N/A	N/A

ATTACHMENT E

GEOCHEMICAL SAMPLING PARAMETERS - METHODS, EQUIPMENT, VOLUME, CONTAINER, PRESERVATION, HOLDING TIME, AND DETECTION RANGES PAGE 3 OF 4

Parameter	Method / Reference	Equipment / Method Chemistry	Sample Volume, Container, Preservation, & Holding Time	Range (mg/L)	Precision (mg/L)	Estimated Detection Limit (mg/L)
Nitrite (NO_2^-)	HACH DR-850 -HACH 8507 -Mod. EPA 354.1 -Mod. SM 419 -CFR 44(85) 25595	Colorimeter / Diazotization	Field. Follow test kit instructions. Avoid agitation and analyze at well head. Filter if turbid as recommended by the manufacture.	0-0.350	$\pm$ 0.001 mg/L with a 0.250 mg/L nitrite nitrogen solution.	0.005
Nitrogen, dissolved	Fixed-base lab -Microseeps gas stripping cell - Vaportech VOA water sample	GC-ECD/RGD/FID Detector	Field bubble-strip sampling required for Microseeps. Ship in glass septum vial (Microseeps) or VOA vial (Vaportech).	N/A	N/A	N/A
Nitrogen, Total Kjeldahl	Fixed-base lab -EPA 351.2	N/A	500 mL plastic/glass container. Cool to 4°C. H_2SO_4 to pH $\leq$ 2. Analyze within 28 days.	N/A	N/A	N/A
Oxidation Reduction Potential	Field Meter - ASTM D-1498	Direct Reading Meter	Field. Do not aerate. Gently agitate probe using flow over ot flow-through method. Analyze immediately at well head.	N/A	N/A	N/A
Oxygen, dissolved	CHEMetrics K-7501, K-7512 -ASTM D 5543-94 -ASTM D 887-92	CHEMets® Vacuum Vials / Rhodazine D and Indigo Carmine	Field. Follow test kit instructions. Avoid agitation and analyze immediately at well head.	0-1 (K-7501) 1-12 (K-7512)	N/A	0.025 1
Oxygen, dissolved	Fixed-base lab -VOA water sample, Vaportech -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	40 mL in VOA vial. 2 to 3 vials by (Vaportech).	N/A	N/A	N/A
Oxygen, dissolved	Fixed-base lab -Microseeps gas stripping cell -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	Field bubble-strip sampling required. Ship in glass septum vial (Microseeps only).	N/A	N/A	N/A
Oxygen, dissolved	HACH OX-DT -HACH 8215 -SM 4500-O-G	Digital Titration / Azide Modification of Winkler Digital Titration Method	Field. Follow test kit instructions. Avoid agitation and analyze immediately at well head.	1-10	N/A	1
Oxygen, dissolved	HACH DR-850 (AccuVac Ampules) LR HRDO Method	-Indigo Carmine Method -Rhadazine D Method	Field. Follow test kit instructions. Avoid agitation and analyze immediately at well head.	0-0.8 ppm 0-10 ppm	0.01 ppm 0.1 ppm	N/A
Oxygen, dissolved	Field Meter	Direct Reading Meter	Analyze immediately at well head, Avoid agitation and analyze immediately at well head. Used for well stabilization measurement parameter only.	N/A	N/A	N/A
pH	Field Meter -SW 9040B	Direct Reading Meter	Analyze immediately at well head.	N/A	N/A	N/A
Phosphate (ortho)	Fixed-base lab -EPA 300	Ion Chromatography	250 mL plastic container. Cool to 4°C. Analyze within 48 hours. Filter if turbid as recommended by the manufacture.	N/A	N/A	N/A
Phosphate, potassium	Fixed-base lab -SW-846 6010B	Inductively Coupled Plasma	250 mL plastic container. Cool to 4°C. Analyze within 48 hours. Filter if turbid as recommended by the manufacture.	N/A	N/A	N/A
Salinity	Field Meter	Direct Reading Meter	Analyze immediately.	N/A	N/A	N/A
Sulfate (SO_4^{-2})	Fixed-base lab	N/A	250 mL plastic container. Cool to 4°C. Analyze within 48 hours. Filter if turbid as recommended by the manufacture.	N/A	N/A	N/A
Sulfate (SO_4^{-2})	HACH DR-850 -HACH 8051 -EPA 375.4	Colorimeter / Turbimetric SulfaVer 4	Field. Follow test kit instructions. Filter if turbid as recommended by the manufacture.	0-70	$\pm$ 0.5 mg/L with a 50 mg/L sulfate solution.	4.9
Sulfide (Hydrogen Sulfide, H_2S)	HACH HS-C -HACH Proprietary -Mod. SM 426 C	Color Chart / Effervescence of H_2S through sulfide reactive paper.	Field. Follow test kit instructions. Avoid agitation and analyze immediately at well head.	0-5	N/A	0.1
Sulfide (S^{-2})	CHEMetrics K-9510 -SM 4500-S^2	CHEMets® Vacuum Vials / Methylene Blue	Field. Follow test kit instructions. Avoid agitation and analyze immediately at well head.	0-1 1-10	N/A	0.1 1

ATTACHMENT E
GEOCHEMICAL SAMPLING PARAMETERS - METHODS, EQUIPMENT, VOLUME, CONTAINER, PRESERVATION, HOLDING TIME, AND DETECTION RANGES
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Parameter	Method / Reference	Equipment / Method Chemistry	Sample Volume, Container, Preservation, & Holding Time	Range (mg/L)	Precision (mg/L)	Estimated Detection Limit (mg/L)
Sulfide (S^{-2})	Fixed-base lab -EPA 376.1/376.2	N/A	1 liter in plastic container, no headspace. NaOH to pH >9. Cool to 4°C. Avoid agitation and analyze within 7 days.	N/A	N/A	N/A
Sulfide (S^{-2})	HACH DR-850 -HACH 8131 -SM 4500-S^{2}	Colorimeter / Methylene Blue	Field. Follow test kit instructions. Avoid agitation and analyze immediately at well head. Pretreatment required for turbid samples as recommended by the manufacture.	0-0.70	$\pm$ 0.02 mg/L with a 0.73 mg/L sulfide solution.	0.01
Sulfide (S^{-2})	HACH HS-WR -SM 4500-S^{2}	Color Disc / Methylene Blue	Field. Follow test kit instructions. Avoid agitation and analyze immediately at well head. Pretreatment required for turbid samples as recommended by the manufacture.	0-11.25	N/A	0.1-2.5
Temperature	Field Meter / Thermometer - E170.1	Direct Reading Meter / Thermometer	Analyze immediately.	N/A	N/A	N/A
Total Organic Carbon (TOC)-Groundwater	Fixed-base lab -E 415.1	N/A	125 mL HDPE. H_2SO_4 to pH < 2.0. Cool to 4°C. Analyze within 28 days.	N/A	N/A	N/A
Turbidity	Field Meter - E 180.1	Direct Reading Meter	Analyze immediately.	N/A	N/A	N/A

N/A = Not applicable.

ATTACHMENT F

FIELD ANALYTICAL LOG SHEET, GEOCHEMICAL PARAMETERS PAGE 1 OF 3

Note: Analyte, method, and/or equipment may be deleted from form if not being performed.

Tetra Tech NUS, Inc.

FIELD ANALYTICAL LOG SHEET
GEOCHEMICAL PARAMETERS

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Project Site Name: ______ Sample ID No.: ______
Project No.: ______ Sample Location: ______
Sampled By: ______ Duplicate: ☐
Field Analyst: ______ Blank: ☐
Field Form Checked as per QA/QC Checklist (initials): ______

SAMPLING DATA:

Date:	Color	pH	S.C.	Temp.	Turbidity	DO	Salinity	ORP (Eh)
Time:	(Visual)	(S.U.)	(mS/cm)	(^{o}C)	(NTU)	(mg/l)	(%)	(+/- mv)
Method:								

SAMPLE COLLECTION/ANALYSIS INFORMATION:

ORP (Eh) (+/- mv)

Electrode Make & Model: ______

Reference Electrode (circle one): Silver-Silver Chloride / Calomel / Hydrogen

Dissolved Oxygen:

Equipment: Chemetrics Test Kit

Concentration: ______ ppm

Range Used:	Range	Method	Concentration ppm
☐	0 to 1 ppm	K-7510	
☐	1 to 12 ppm	K-7512	

Analysis Time: ______

Equipment: HACH Digital Titrator OX-DT

Analysis Time: ______

Range Used:	Range	Sample Vol.	Cartridge	Multiplier
☐	1-5 mg/L	200 ml	0.200 N	0.01
☐	2-10 mg/L	100 ml	0.200 N	0.02

Titration Count	Multiplier		Concentration
______	x 0.01	=	mg/L
______	x 0.02	=	mg/L

Notes:

Carbon Dioxide:

Equipment: Chemetrics Test Kit

Concentration: ______ ppm

Range Used:	Range	Method	Concentration ppm
☐	10 to 100 ppm	K-1910	
☐	100 to 1000 ppm	K-1920	
☐	250 to 2500 ppm	K-1925	

Analysis Time: ______

Equipment: HACH Digital Titrator CA-DT

Range Used:	Range	Sample Vol.	Cartridge	Multiplier
☐	10-50 mg/L	200 ml	0.3636 N	0.1
☐	20-100 mg/L	100 ml	0.3636 N	0.2
☐	100-400 mg/L	200 ml	3.636 N	1.0
☐	200-1000 mg/L	100 ml	3.636 N	2.0

Titration Count			Concentration
______	x 0.1	=	mg/L
______	x 0.2	=	mg/L
______	x 1.0	=	mg/L
______	x 2.0	=	mg/L

Standard Additions: ☐ Titrant Molarity: ______ Digits Required: 1st.: ______ 2nd.: ______ 3rd.: ______

Notes:

Hydrogen, dissolved

Equipment: Bubble strip sampling field method

Start stripper at ______ (time)
End stripper at ______ (time)
Total stripper time ______
Pump rate ______ milliliters/minute

ATTACHMENT F

FIELD ANALYTICAL LOG SHEET, GEOCHEMICAL PARAMETERS
PAGE 2 OF 3

Note: Analyte, method, and/or equipment may be deleted from form if not being performed.

Tetra Tech NUS, Inc.

FIELD ANALYTICAL LOG SHEET
GEOCHEMICAL PARAMETERS

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Project Site Name: ____________ Sample ID No.: ____________
Project No.: ____________ Sample Location: ____________
Sampled By: ____________ Duplicate: ☐
Field Analyst: Blank: ☐

Alkalinity:

Equipment: Chemetrics Test Kit

Concentration: ________ ppm

Range Used:	Range	Method	Concentration ppm
☐	10 to 100 ppm	K-9810	
☐	50 to 500 ppm	K-9815	
☐	100 to 1000 ppm	K-9820	

Analysis Time: ________

Filtered: ☐

Equipment: HACH Digital Titrator AL-DT

Range Used	Range	Sample Vol.	Cartridge	Multiplier	Titration Count	Multiplier	Concentration
☐	10-40 mg/L	100 ml	0.1600 N	0.1	____ & ____	x 0.1	= mg/L
☐	40-160 mg/L	25 ml	0.1600 N	0.4	____ & ____	x 0.4	= mg/L
☐	100-400 mg/L	100 ml	1.600 N	1.0	____ & ____	x 1.0	= mg/L
☐	200-800 mg/L	50 ml	1.600 N	2.0	____ & ____	x 2.0	= mg/L
☐	500-2000 mg/L	20 ml	1.600 N	5.0	____ & ____	x 5.0	= mg/L
☐	1000-4000 mg/L	10 ml	1.600 N	10.0	____ & ____	x 10.0	= mg/L

Parameter:	Hydroxide	Carbonate	Bicarbonate
Relationship:			

Standard Additions: ☐ Titrant Molarity: ________ Digits Required 1st.: ______ 2nd.: ______ 3rd.: ______

Notes:

Ferrous Iron (Fe^{2+}):

Equipment: DR-850 DR-8__ Range: 0 - 3.00 mg/L Concentration: ________ ppm

Program/Module: 500nm 33

Analysis Time: ________

Equipment: IR-18C Color Wheel Range: 0 - 10 mg/L

Notes: Filtered: ☐

Hydrogen Sulfide (H_2S): Range: 0 - 5 mg/L

Equipment: HS-C Other: ________ Concentration: ________ ppm

Exceeded 5.0 mg/L range on color chart ☐ Analysis Time: ________

Notes:

Sulfide (S^{2-}):

Equipment: Chemetrics Test Kit Range: 0 - 10 mg/L Concentration: ________ ppm

Range Used:	Range	Method	Concentration ppm
☐	0 to 1 ppm	K-9510	
☐	1 to 10 ppm	K-9510	

Analysis Time: ________

Filtered ☐

Equipment: DR-850 DR-8__ Range: 0 - 0.70 mg/L

Program/Module: 610nm 93

Notes:

ATTACHMENT F

FIELD ANALYTICAL LOG SHEET, GEOCHEMICAL PARAMETERS PAGE 3 OF 3

Note: Analyte, method, and/or equipment may be deleted from form if not being performed.

Tetra Tech NUS, Inc.

FIELD ANALYTICAL LOG SHEET
GEOCHEMICAL PARAMETERS

Page __ of __

Project Site Name: ______ Sample ID No.: ______
Project No.: ______ Sample Location: ______
Sampled By: ______ Duplicate: ☐
Field Analyst: ______ Blank: ☐

Sulfate (SO_4^{2-}):

Equipment: DR-850 DR-8__ Range: 0 - 70 mg/L Concentration: ______ ppm
Program/Module: ______ 91 Analysis Time: ______
Standard Solution: ☐ Results: ______ Filtered: ☐
Standard Additions: ☐ Digits Required: 0.1ml:______ 0.2ml:______ 0.3ml:______
Notes:

Nitrate (NO_3^--N):

Equipment: DR-850 DR-8__ Range: 0 - 0.50 mg/L(1) Concentration: ______ ppm
Program/Module: 55 Analysis Time: ______ Filtered: ☐
Standard Solution: ☐ Results: ______ Nitrite Interference Treatment: ☐ Reagent Blank Correction: ☐
Standard Additions: ☐ Digits Required: 0.1ml:______ 0.2ml:______ 0.3ml:______
Alternate forms: NO_2 ______ $NaNO_2$ ______ mg/L

Notes (1): If results are over limit use dilution method at step 3, 5ml sample 10ml DI result X3, range upto 1.5mg/L

Notes:

Nitrite (NO_2^--N):

Concentration: ______ ppm
Equipment: DR-850 DR-8__ Range: 0 - 0.350 mg/L Analysis Time: ______ Filtered: ☐
Program/Module: 62
Standard Solution: ☐ Results: ______ Reagent Blank Correction: ☐
Notes:

Manganese (Mn^{2+}):

Concentration: ______ ppm
Equipment: DR-850 DR-8__ Range: 0 - 20.0 mg/L Analysis Time: ______ Filtered: ☐
Program/Module: 525nm 41
Standard Solution: ☐ Results: ______ Digestion: ☐ Reagent Blank Correction: ☐
Standard Additions: ☐ Digits Required: 0.1ml:______ 0.2ml:______ 0.3ml:______

Equipment: HACH MN-5 Range: 0 - 3 mg/L
Notes:

QA/QC Checklist:

All data fields have been completed as necessary: ☐
Correct measurement units are cited in the SAMPLING DATA block: ☐
Values cited in the SAMPLING DATA block are consistent with the Groundwater Sample Log Sheet: ☐
Mulitplication is correct for each *Multiplier* table: ☐
Final calulated concentration is within the appropriate *Range Used* block: ☐
Alkalinity *Relationship* is determined appropriatly as per manufacturer (HACH) instructions: ☐
QA/QC sample (e.g., Std. Additions, etc.) frequency is appropriate as per the project planning documents: ☐
Nitrite Interference treatment was used for Nitrate test if Nitrite was detected: ☐
Title block on each page of form is initialized by person who performed this QA/QC Checklist: ☐

TETRA TECH NUS, INC.	STANDARD OPERATING PROCEDURES	Number: GH-2.8	Page: 1 of 12
		Effective Date: 09/03	Revision: 3
		Applicability: Tetra Tech NUS, Inc.	
		Prepared: Earth Sciences Department	
Subject: GROUNDWATER MONITORING WELL INSTALLATION		Approved: D. Senovich	

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ATTACHMENTS

1.0 PURPOSE

This procedure provides general guidance and information pertaining to proper monitoring well design, installation, and development.

2.0 SCOPE

This procedure is applicable to the construction of monitoring wells. The methods described herein may be modified by project-specific requirements for monitoring well construction. In addition, many regulatory agencies have specific regulations pertaining to monitoring well construction and permitting. These requirements must be determined during the project planning phases of the investigation, and any required permits must be obtained before field work begins. Innovative monitoring well installation techniques, which typically are not used, will be discussed only generally in this procedure.

3.0 GLOSSARY

Monitoring Well - A well which is screened, cased, and sealed which is capable of providing a groundwater level and groundwater sample representative of the zone being monitored. Some monitoring wells may be constructed as open boreholes.

Piezometer - A pipe or tube inserted into the water bearing zone, typically open to water flow at the bottom and to the atmosphere at the top, and used to measure water level elevations. Piezometers may range in size from 1/2-inch-diameter plastic tubes to well points or monitoring wells.

Potentiometric Surface - The surface representative of the level to which water will rise in a well cased to the screened aquifer.

Well Point (Drive Point) - A screened or perforated tube (Typically 1-1/4 or 2 inches in diameter) with a solid, conical, hardened point at one end, which is attached to a riser pipe and driven into the ground with a sledge hammer, drop weight, or mechanical vibrator. Well points may be used for groundwater injection and recovery, as piezometers (i.e., to measure water levels) or to provide groundwater samples for water quality data.

4.0 RESPONSIBILITIES

Driller - The driller provides adequate and operable equipment, sufficient quantities of materials, and an experienced and efficient labor force capable of performing all phases of proper monitoring well installation and construction. The driller may also be responsible for obtaining, in advance, any required permits for monitoring well installation and construction.

Field Geologist - The field geologist supervises and documents well installation and construction performed by the driller, and insures that well construction is adequate to provide representative groundwater data from the monitored interval. Geotechnical engineers, field technicians, or other suitable trained personnel may also serve in this capacity.

5.0 PROCEDURES

5.1 Equipment/Items Needed

Below is a list of items that may be needed when installing a monitoring well or piezometer:

- Health and safety equipment (hard hats, safety glasses, etc.) as required by the Site Safety Officer.
- Well drilling and installation equipment with associated materials (typically supplied by the driller).
- Hydrogeologic equipment (weighted engineer's tape, water level indicator, retractable engineers rule, electronic calculator, clipboard, mirror and flashlight - for observing downhole activities, paint and ink marker for marking monitoring wells, sample jars, well installation forms, and a field notebook).
- Drive point installation tools (sledge hammer, drop hammer, or mechanical vibrator; tripod, pipe wrenches, drive points, riser pipe, and end caps).

5.2 Well Design

The objectives and intended use for each monitoring well must be clearly defined before the monitoring system is designed. Within the monitoring system, different monitoring wells may serve different purposes and, therefore, require different types of construction. During all phases of the well design, attention must be given to clearly documenting the basis for design decisions, the details of well construction, and the materials used. The objectives for installing the monitoring wells may include:

- Determining groundwater flow directions and velocities.
- Sampling or monitoring for trace contaminants.
- Determining aquifer characteristics (e.g., hydraulic conductivity).

Siting of monitoring wells shall be performed after a preliminary estimation of the groundwater flow direction. In most cases, groundwater flow directions and potential well locations can be determined by an experienced hydrogeologist through the review of geologic data and the site terrain. In addition, data from production wells or other monitoring wells in the area may be used to determine the groundwater flow direction. If these methods cannot be used, piezometers, which are relatively inexpensive to install, may have to be installed in a preliminary investigative phase to determine groundwater flow direction.

5.2.1 Well Depth, Diameter, and Monitored Interval

The well depth, diameter, and monitored interval must be tailored to the specific monitoring needs of each investigation. Specification of these items generally depends on the purpose of the monitoring system and the characteristics of the hydrogeologic system being monitored. Wells of different depth, diameter, and monitored interval can be employed in the same groundwater monitoring system. For instance, varying the monitored interval in several wells, at the same location (cluster wells) can help to determine the vertical gradient and the depths at which contaminants are present. Conversely, a fully penetrating well is usually not used to quantify or vertically locate a contaminant plume, since groundwater samples collected in wells that are screened over the full thickness of the water-bearing zone will be representative of average conditions across the entire monitored interval. However, fully penetrating wells can be used to establish the existence of contamination in the water-bearing zone. The well diameter desired depends upon the hydraulic characteristics of the water-bearing zone, sampling requirements, drilling method and cost.

The decision concerning the monitored interval and well depth is based on the following (and possibly other) information:

- The vertical location of the contaminant source in relation to the water-bearing zone.
- The depth, thickness and uniformity of the water-bearing zone.
- The anticipated depth, thickness, and characteristics (e.g., density relative to water) of the contaminant plume.
- Fluctuation in groundwater levels (due to pumping, tidal influences, or natural recharge/discharge events).
- The presence and location of contaminants encountered during drilling.
- Whether the purpose of the installation is for determining existence or non-existence of contamination or if a particular stratigraphic zone is being investigated.
- The analysis of borehole geophysical logs.

In most situations where groundwater flow lines are horizontal, depending on the purpose of the well and the site conditions, monitored intervals are 20 feet or less. Shorter screen lengths (5 feet or less) are usually required where flow lines are not horizontal, (i.e., if the wells are to be used for accurate measurement of the potentiometric head at a specific point).

Many factors influence the diameter of a monitoring well. The diameter of the monitoring well depends on the application. In determining well diameter, the following needs must be considered:

- Adequate water volume for sampling.
- Drilling methodology.
- Type of sampling device to be used.
- Costs.

Standard monitoring well diameters are 2, 4, 6, or 8 inches. Drive points are typically 1-1/4 or 2 inches in diameter. For monitoring programs which require screened monitoring wells, either a 2-inch or 4-inch-diameter well is preferred. Typically, well diameters greater than 4 inches are used in monitoring programs in which open-hole bedrock monitoring wells are used. With smaller diameter wells, the volume of stagnant water in the well is minimized, and well construction costs are reduced; however, the sampling devices that can be used are limited.

In specifying well diameter, sampling requirements must be considered (up to a total of 4 gallons of water may be required for a single sample to account for full organic and inorganic analyses, and split samples), particularly if the monitored formation is known to be a low-yielding formation. The unit volume of water contained within a monitoring well is dependent on the well diameter as follows:

Casing Inside Diameter (Inch)	Standing Water Length to Obtain 1 Gallon Water (Feet)
2	6.13
4	1.53
6	0.68

If a well recharges quickly after purging, then well diameter may not be an important factor regarding sample volume requirements.

Pumping tests for determining aquifer characteristics may require larger diameter wells (for installation of high capacity pumps); however, in small-diameter wells in-situ permeability tests can be performed during drilling or after well installation is completed.

5.2.2 Riser Pipe and Screen Materials

Well materials are specified by diameter, type of material, and thickness of pipe. Well screens require an additional specification of slot size. Thickness of pipe is referred to as "Schedule" for polyvinyl chloride (PVC) casing and is usually Schedule 40 (thinner wall) or 80 (thicker wall). Steel pipe thickness is often referred to as "Strength". Standard Strength is usually adequate for monitoring well purposes. With larger diameter pipe, the wall thickness must be greater to maintain adequate strength. The required thickness is also dependent on the method of installation; risers for drive points require greater strength than wells installed inside drilled borings.

The selection of well screen and riser materials depends on the method of drilling, the type of subsurface materials the well penetrates, the type of contamination expected, and natural water quality and depth. Cost and the level of accuracy required are also important. The materials generally available are Teflon, stainless steel, PVC galvanized steel, and carbon steel. Each has advantages and limitations (see Attachment A of this guideline for an extensive presentation on this topic). The two most commonly used materials are PVC and stainless steel. Properties of these two materials are compared in Attachment B. Stainless steel is a good choice where trace metals or organic sampling is required; however, costs are high. Teflon materials are extremely expensive, but are relatively inert and provide the least opportunity for water contamination due to well materials. PVC has many advantages, including low cost, excellent availability, light weight, ease of manipulation, and widespread acceptance. The crushing strength of PVC may limit the depth of installation, but the use of Schedule 80 materials may overcome some of the problems associated with depth. However, the smaller inside diameter of Schedule 80 pipe may be an important factor when considering the size of bailers or pumps required for sampling or testing. Due to this problem, the minimum well pipe size recommended for Schedule 80 wells is 4-inch I.D.

Screens and risers may have to be decontaminated before use because oil-based preservatives and oil used during thread cutting and screen manufacturing may contaminate samples. Metal pipe may corrode and release metal ions or chemically react with organic constituents, but this is considered a minor issue. Galvanized steel is not recommended where samples may be collected for metals analyses, as zinc and cadmium levels in groundwater samples may become elevated from leaching of the zinc coating.

Threaded, flush-joint casing is most often preferred for monitoring well applications. PVC, Teflon, and steel can all be obtained with threaded joints. Welded-joint steel casing is also acceptable. Glued PVC may release organic contaminants into the well, and therefore, should not be used if the well is to be sampled for organic constituents.

When the water-bearing zone is in consolidated bedrock, such as limestone or fractured granite, a well screen is often not necessary (the well is simply an open hole in bedrock). Unconsolidated materials, such as sands, clay, and silts require a screen. A screen slot size of 0.010 or 0.020 inch is generally used when a screen is necessary, and the annular borehole space around the screened interval is artificially packed with an appropriately sized sand, selected based on formation grain size. The slot size controls the quantity of water entering the well and prevents entry of natural materials or sand pack. The screen shall pass no more than 10 percent of the pack material, or in-situ aquifer material. The site geologist shall specify the combination of screen slot size and sand pack which will be compatible with the water-bearing zone, to maximize groundwater inflow and minimize head losses and movement of fines into the wells. For example, as a standard procedure, a Morie No. 1 or No. 10 to No. 20 U.S. Standard Sieve size filter pack is typically appropriate for a 0.020-inch slot screen; however, a No. 20 to No. 40 U.S. Standard Sieve size filter pack is typically appropriate for a 0.010-inch slot screen.

5.2.3 Annular Materials

Materials placed in the annular space between the borehole and riser pipe and screen include a sand pack when necessary, a bentonite seal, and cement-bentonite grout. The sand pack is usually a medium- to coarse-grained poorly graded, silica sand and should relate to the grain size of the aquifer sediments. The quantity of sand placed in the annular space is dependent upon the length of the screened interval, but should always extend at least 1 foot above the top of the screen. At least 1 to 3 feet of bentonite pellets or equivalent shall be placed above the sand pack. Cement-bentonite grout (or equivalent) is then placed to extent from the top of the bentonite pellets to the ground surface.

On occasion, and with the concurrence of the involved regulatory agencies, monitoring wells may be packed naturally (i.e., no artificial sand pack installed). In this case, the natural formation material is allowed to collapse around the well screen after the well is installed. This method has been used where the formation material itself is a relatively uniform grain size, or when artificial sand packing is not possible due to borehole collapse.

Bentonite expands by absorbing water and provides a seal between the screened interval and the overlying portion of the annular space and formation. Cement-bentonite grout is placed on top of the bentonite pellets, extending to the surface. The grout effectively seals the remaining borehole annulus and eliminates the possibility for surface infiltration reaching the screened interval. Grouting also replaces material removed during drilling and prevents hole collapse and subsidence around the well. A tremie pipe should be used to introduce grout from the bottom upward, to prevent bridging, and to provide a better seal. In shallow boreholes that don't collapse, it may be more practical to pour the grout from the surface without a tremie pipe.

Grout is a general term which has several different connotations. For all practical purposes within the monitoring well installation industry, grout refers to the solidified material which is installed and occupies the annular space above the bentonite pellet seal. Grout, most of the time, is made up of one or two assemblages of material, (e.g., cement and/or bentonite). A cement-bentonite grout, which is the most common type of grout used in monitoring well completions, normally is a mixture of cement, bentonite, and water at a ratio of one 90-pound bag of Portland Type I cement, plus 3 to 5 pounds of granular or flake-type bentonite, and 6-7 gallons of water. A neat cement consists of one ninety-pound bag of Portland Type I cement and 6-7 gallons of water. A bentonite slurry (bentonite and water mixed to a thick but pumpable mixture) is sometimes used instead of grout for deep well installations where placement of bentonite pellets is difficult. Bentonite chips are also occasionally used for annular backfill in place of grout.

In certain cases, the borehole may be drilled to a depth greater than the anticipated well installation depth. For these cases, the well shall be backfilled to the desired depth with bentonite pellets/chips or sand. A short (1- to 2-foot) section of capped riser pipe sump is sometimes installed immediately below the screen, as a silt reservoir, when significant post-development silting is anticipated. This will ensure that the entire screen surface remains unobstructed.

5.2.4 Protective Casing

When the well is completed and grouted to the surface, a protective steel casing is typically placed over the top of the well. This casing generally has a hinged cap and can be locked to prevent vandalism. The protective casing has a larger diameter than the well and is set into the wet cement grout over the well upon completion. In addition, one hole is drilled just above the cement collar through the protective casing which acts as a weep hole for the flow of water which may enter the annulus during well development, purging, or sampling.

A protective casing which is level with the ground surface (flush-mounted) is used in roadway or parking lot applications where the top of a monitoring well must be below the pavement. The top of the riser pipe is placed 4 to 5 inches below the pavement, and a locking protective casing is cemented in place to 3 inches below the pavement. A large diameter, manhole-type protective collar is set into the wet cement around the well with the top set level with or slightly above the pavement. An appropriately-sized id is placed over the protective sleeve. The cement should be slightly mounded to direct pooled water away from the well head.

5.3 Monitoring Well Installation

Pertinent data regarding monitoring well installation shall be recorded on log sheets as depicted and discussed in SOP SA-6.3. Attachments to this referenced SOP illustrate terms and physical construction of various types of monitoring wells.

5.3.1 Monitoring Wells in Unconsolidated Sediments

After the borehole is drilled to the desired depth, well installation can begin. The procedure for well installation will partially be dictated by the stability of the formation in which the well is being placed. If the borehole collapses immediately after the drilling tools are withdrawn, then a temporary casing must be installed and well installation will proceed through the center of the temporary casing, and continue as the temporary casing is withdrawn from the borehole. In the case of hollow-stem auger drilling, the augers will act to stabilize the borehole during well installation.

Before the screen and riser pipe are lowered into the borehole, all pipe and screen sections should be measured with an engineer's rule to ensure proper placement. When measuring sections, the threads on one end of the pipe or screen must be excluded while measuring, since the pipe and screen sections are screwed flush together.

After the screen and riser pipe are lowered through the temporary casing, the sand pack can be installed. A weighted tape measure must be used during the installation procedure to carefully monitor installation progress. The sand is slowly poured into the annulus between the riser pipe and temporary casing, as the casing is withdrawn. Sand should always be kept within the temporary casing during withdrawal in order to ensure an adequate sand pack. However, if too much sand is within the temporary casing (greater than 1 foot above the bottom of the casing) bridging between the temporary casing and riser pipe may occur. Centralizers may be used at the geologist's discretion, one above and one below the screen, to assure enough annular space for sand pack placement.

After the sand pack is installed to the desired depth (at least 1 foot above the top of the screen), then the bentonite pellet seal (or equivalent), can be installed in the same manner as the sand pack. At least 1 to 3 feet of bentonite pellets should be installed above the sand pack. Pellets should be added slowly and their fall monitored closely to ensure that bridging does not occur.

The cement-bentonite grout is then mixed and tremied into the annulus as the temporary casing or augers are withdrawn. Finally, the protective casing can be installed as detailed in Section 5.2.4.

5.3.2 Confining Layer Monitoring Wells

When drilling and installing a well in a confined aquifer, proper well installation techniques must be applied to avoid cross contamination between aquifers. Under most conditions, this can be accomplished by installing double-cased wells. This is accomplished by drilling a large-diameter boring through the upper aquifer, 1 to 5 feet into the underlying confining layer, and setting and pressure grouting or tremie grouting a large-diameter casing into the confining layer. The grout material must fill the space between the native material and the outer casing. A smaller diameter boring is then continued through the confining layer for installation of the monitoring well as detailed for overburden monitoring wells. Sufficient time (determined by the field geologist), must be allowed for setting of the grout prior to drilling through the confined layer.

5.3.3 Bedrock Monitoring Wells

When installing bedrock monitoring wells, a large diameter boring is drilled through the overburden and approximately 5 –10 feet into bedrock. A casing (typically steel) is installed and either pressure grouted or tremie grouted in place. After the grout has cured, a smaller diameter boring is continued into bedrock to the desired depth. If the boring does not collapse, the well can be left open, and a screen is not necessary. If the boring collapses, then a screen is required and can be installed as detailed for overburden monitoring wells. If a screen is to be used, then the casing which is installed through the overburden and into the bedrock does not require grouting and can be removed when the final well installation is completed.

5.3.4 Drive Points

Drive points can be installed with either a sledge hammer, drop hammer, or a mechanical vibrator. The screen section is threaded and tightened onto the riser pipe with pipe wrenches. The drive point is simply pounded into the subsurface to the desired depth. If a heavy drop hammer is used, then a tripod and pulley setup is required to lift the hammer. Drive points typically cannot be manually driven to depths exceeding 10 feet.

Direct push sampling/monitoring point installation methods, using a direct push rig or drilling rig, are described in SOP SA-2.5.

5.3.5 Innovative Monitoring Well Installation Techniques

Certain innovative sampling devices have proven advantageous. These devices are essentially screened samplers installed in a borehole with only small-diameter tubes extending to the surface. This reduces drilling costs, decreases the volume of stagnant water, and provides a sampling system that minimizes cross-contamination from sampling equipment. Four manufacturers of these samplers include Timco Manufacturing Company, Inc., of Prairie du Sac, Wisconsin, BARCAD Systems, Inc., of Concord, Massachusetts, Westbay Instruments Ltd. of Vancouver, British Columbia, Canada and the University of Waterloo at Waterloo, Ontario, Canada.. Each manufacturer offers various construction materials.

5.4 Well Development Methods

The purpose of well development is to stabilize and increase the permeability of the gravel pack around the well screen, and to restore the permeability of the formation which may have been reduced by drilling operations. Wells are typically developed until all fine material and drilling water is removed from the well. Sequential measurements of pH, conductivity, turbidity, and temperature taken during development may yield information (stabilized values) regarding whether sufficient development has been performed. The selection of the well development method shall be made by the field geologist and is based on the drilling methods, well construction and installation details, and the characteristics of the formation that the well is screened in. The primary methods of well development are summarized below. A more detailed discussion may be found in Driscoll (1986).

5.4.1 Overpumping and Backwashing

Wells may be developed by alternatively drawing the water level down at a high rate (by pumping or bailing) and then reversing the flow direction (backwashing) so that water is passing from the well into the formation. This back and forth movement of water through the well screen and gravel pack serves to remove fines from the formation immediately adjacent to the well, while preventing bridging (wedging) of sand grains. Backwashing can be accomplished by several methods, including pouring water into the well and then bailing, starting and stopping a pump intermittently to change water levels, or forcing water into the well under pressure through a water-tight fitting ("rawhiding"). Care should be taken when backwashing not to apply too much pressure, which could damage or destroy the well screen.

5.4.2 Surging with a Surge Plunger

A surge plunger (also called a surge block) is approximately the same diameter as the well casing and is aggressively moved up and down within the well to agitate the water, causing it to move in and out of the screens. This movement of water pulls fine materials into the well, where they may be removed by any of several methods, and prevents bridging of sand particles in the gravel pack. There are two basic types of surge plungers; solid and valved surge plungers. In formations with low yields, a valved surge plunger may be preferred, as solid plungers tend to force water out of the well at a greater rate than it will flow back in. Valved plungers are designed to produce a greater inflow than outflow of water during surging.

5.4.3 Compressed Air

Compressed air can be used to develop a well by either of two methods: backwashing or surging. Backwashing is done by forcing water out through the screens, using increasing air pressure inside a sealed well, then releasing the pressurized air to allow the water to flow back into the well. Care should be taken when using this method so that the water level does not drop below the top of the screen, thus introducing air into the formation and reducing well yield. Surging, or the "open well" method, consists of alternately releasing large volumes of air suddenly into an open well below the water level to produce a strong surge by virtue of the resistance of water head, friction, and inertia. Pumping of the well is subsequently done using the air lift method.

5.4.4 High Velocity Jetting

In the high velocity jetting method, water is forced at high velocities from a plunger-type device and through the well screen to loosen fine particles from the sand pack and surrounding formation. The jetting tool is slowly rotated and raised and lowered along the length of the well screen to develop the entire screened area. Jetting using a hose lowered into the well may also be effective. The fines washed into the screen during this process can then be bailed or pumped from the well.

6.0 RECORDS

A critical part of monitoring well installation is recording of all significant details and events in the site logbook or field notebook. The geologist must record the exact depths of significant hydrogeological features, screen placement, gravel pack placement, and bentonite placement.

A Monitoring Well Sheet (see Attachments to SOP SA-6.3) shall be completed, ensuring the uniform recording of data for each installation and rapid identification of missing information. Well depth, length, materials of construction, length and openings of screen, length and type of riser, and depth and type of all backfill materials shall be recorded. Additional information shall include location, installation date, problems encountered, water levels before and after well installation, cross-reference to the geologic boring log, and methods used during the installation and development process. Documentation is very important to prevent problems involving questionable sample validity. Somewhat different information will need to be recorded, depending on whether the well is completed in overburden (single- or double-cased), as a cased well in bedrock, or as an open hole in bedrock.

The quantities of sand, bentonite, and grout placed in the well are also important. The geologist shall calculate the annular space volume and have an idea of the quantity of material needed to fill the annular space. Volumes of backfill significantly higher than the calculated volume may indicate a problem such as a large cavity, while a smaller backfill volume may indicate a cave-in or bridging of the backfill materials. Any problems with rig operation or down-time shall be recorded and may affect the driller's final fee.

7.0 REFERENCES

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U.S. EPA, 1980. Procedures Manual for Groundwater Monitoring of Solid Waste Disposal Facilities. Publication SW-611, Office of Solid Waste, U.S. EPA, Washington, D.C.

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ATTACHMENT A

RELATIVE COMPATIBILITY OF RIGID WELL CASING MATERIAL (PERCENT)

Potentially-Deteriorating Substance	Type of Casing Material						
	PVC 1	Galvanized Steel	Carbon Steel	Lo-carbon Steel	Stainless Steel 304	Stainless Steel 316	Teflon*
Buffered Weak Acid	100	56	51	59	97	100	100
Weak Acid	98	59	43	47	96	100	100
Mineral Acid/ High Solids Content	100	48	57	60	80	82	100
Aqueous/Organic Mixtures	64	69	73	73	98	100	100
Percent Overall Rating	91	58	56	59	93	96	100

Preliminary Ranking of Rigid Materials:

1 Teflon®
2 Stainless Steel 316
3. Stainless Steel 304
4 PVC 1
5 Lo-Carbon Steel
6 Galvanized Steel
7 Carbon Steel

* Trademark of DuPont

RELATIVE COMPATIBILITY OF SEMI-RIGID OR ELASTOMERIC MATERIALS (PERCENT)

Potentially-Deteriorating Substance	Type of Casing Material								
	PVC Flexible	PP	PE Conv.	PE Linear	PMM	Viton®*	Silicone	Neoprene	Teflon®*
Buffered Weak Acid	97	97	100	97	90	92	87	85	100
Weak Acid	92	90	94	96	78	78	75	75	100
Mineral Acid/ High Solids Content	100	100	100	100	95	100	78	82	100
Aqueous/Organic Mixtures	62	71	40	60	49	78	49	44	100
Percent Overall Rating	88	90	84	88	78	87	72	72	100

Preliminary Ranking of Semi-Rigid or Elastomeric Materials:

1 Teflon®
2 Polypropylene (PP)
3. PVC Flexible/PE Linear
4 Viton®
5 PE Conventional
6 Plexiglas/Lucite (PMM)
7 Silicone/Neoprene

* Trademark of DuPont

Source: Barcelona et al., 1983

ATTACHMENT B

COMPARISON OF STAINLESS STEEL AND PVC FOR MONITORING WELL CONSTRUCTION

Characteristic	Stainless Steel	PVC
Strength	Use in deep wells to prevent compression and closing of screen/riser.	Use when shear and compressive strength are not critical.
Weight	Relatively heavier.	Light-weight; floats in water.
Cost	Relatively expensive.	Relatively inexpensive.
Corrosivity	Deteriorates more rapidly in corrosive water.	Non-corrosive -- may deteriorate in presence of ketones, aromatics, alkyl sulfides, or some chlorinated hydrocarbons.
Ease of Use	Difficult to adjust size or length in the field.	Easy to handle and work with in the field.
Preparation for Use	Should be steam cleaned if organics will be subsequently sampled.	Never use glue fittings -- pipes should be threaded or pressure fitted. Should be steam cleaned when used for monitoring wells.
Interaction with Contaminants*	May sorb organic or inorganic substances when oxidized.	May sorb or release organic substances.

* See also Attachment A.

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		Prepared: Earth Sciences Department	
Subject: FIELD DOCUMENTATION		Approved: D. Senovich	

TABLE OF CONTENTS

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to identify and designate the field data record forms, logs and reports generally initiated and maintained for documenting Tetra Tech NUS field activities.

2.0 SCOPE

Documents presented within this procedure (or equivalents) shall be used for all Tetra Tech NUS field activities, as applicable. Other or additional documents may be required by specific client contracts or project planning documents.

3.0 GLOSSARY

None

4.0 RESPONSIBILITIES

Project Manager (PM) - The Project Manager is responsible for obtaining hardbound, controlled-distribution logbooks (from the appropriate source), as needed. In addition, the Project Manager is responsible for placing all field documentation used in site activities (i.e., records, field reports, sample data sheets, field notebooks, and the site logbook) in the project's central file upon the completion of field work.

Field Operations Leader (FOL) - The Field Operations Leader is responsible for ensuring that the site logbook, notebooks, and all appropriate and current forms and field reports illustrated in this guideline (and any additional forms required by the contract) are correctly used, accurately filled out, and completed in the required time-frame.

5.0 PROCEDURES

5.1 Site Logbook

5.1.1 General

The site logbook is a hard-bound, paginated, controlled-distribution record book in which all major onsite activities are documented. At a minimum, the following activities/events shall be recorded or referenced (daily) in the site logbook:

- All field personnel present
- Arrival/departure of site visitors
- Time and date of H&S training
- Arrival/departure of equipment
- Time and date of equipment calibration
- Start and/or completion of borehole, trench, monitoring well installation, etc.
- Daily onsite activities performed each day
- Sample pickup information
- Health and Safety issues (level of protection observed, etc.)
- Weather conditions

A site logbook shall be maintained for each project. The site logbook shall be initiated at the start of the first onsite activity (e.g., site visit or initial reconnaissance survey). Entries are to be made for every day that onsite activities take place which involve Tetra Tech NUS or subcontractor personnel. Upon completion of the fieldwork, the site logbook must become part of the project's central file.

The following information must be recorded on the cover of each site logbook:

- Project name
- Tetra Tech NUS project number
- Sequential book number
- Start date
- End date

Information recorded daily in the site logbook need not be duplicated in other field notebooks (see Section 5.2), but must summarize the contents of these other notebooks and refer to specific page locations in these notebooks for detailed information (where applicable). An example of a typical site logbook entry is shown in Attachment A.

If measurements are made at any location, the measurements and equipment used must either be recorded in the site logbook or reference must be made to the field notebook in which the measurements are recorded (see Attachment A).

All logbook, notebook, and log sheet entries shall be made in indelible ink (black pen is preferred). No erasures are permitted. If an incorrect entry is made, the entry shall be crossed out with a single strike mark, and initialed and dated. At the completion of entries by any individual, the logbook pages used must be signed and dated. The site logbook must also be signed by the Field Operations Leader at the end of each day.

5.1.2 Photographs

When movies, slides, or photographs are taken of a site or any monitoring location, they must be numbered sequentially to correspond to logbook/notebook entries. The name of the photographer, date, time, site location, site description, and weather conditions must be entered in the logbook/notebook as the photographs are taken. A series entry may be used for rapid-sequence photographs. The photographer is not required to record the aperture settings and shutter speeds for photographs taken within the normal automatic exposure range. However, special lenses, films, filters, and other image-enhancement techniques must be noted in the logbook/notebook. If possible, such techniques shall be avoided, since they can adversely affect the accuracy of photographs. Chain-of-custody procedures depend upon the subject matter, type of camera (digital or film), and the processing it requires. Film used for aerial photography, confidential information, or criminal investigation require chain-of-custody procedures. Once processed, the slides of photographic prints shall be consecutively numbered and labeled according to the logbook/notebook descriptions. The site photographs and associated negatives and/or digitally saved images to compact disks must be docketed into the project's central file.

5.2 Field Notebooks

Key field team personnel may maintain a separate dedicated field notebook to document the pertinent field activities conducted directly under their supervision. For example, on large projects with multiple investigative sites and varying operating conditions, the Health and Safety Officer may elect to maintain a separate field notebook. Where several drill rigs are in operation simultaneously, each site geologist assigned to oversee a rig must maintain a field notebook.

5.3 Field Forms

All Tetra Tech NUS field forms (see list in Section 6.0 of this SOP) can be found on the company's intranet site (http://intranet.ttnus.com) under Field Log Sheets. Forms may be altered or revised for project-specific needs contingent upon client approval. Care must be taken to ensure that all essential information can be documented. Guidelines for completing these forms can be found in the related sampling SOP.

5.3.1 Sample Collection, Labeling, Shipment, Request for Analysis, and Field Test Results

5.3.1.1 Sample Log Sheet

Sample Log Sheets are used to record specified types of data while sampling. The data recorded on these sheets are useful in describing the sample as well as pointing out any problems, difficulties, or irregularities encountered during sampling. A log sheet must be completed for each sample obtained, including field quality control (QC) samples.

5.3.1.2 Sample Label

A typical sample label is illustrated in Attachment B. Adhesive labels must be completed and applied to every sample container. Sample labels can usually be obtained from the appropriate Program source electronically generated in-house, or are supplied from the laboratory subcontractor.

5.3.1.3 Chain-of-Custody Record Form

The Chain-of-Custody (COC) Record is a multi-part form that is initiated as samples are acquired and accompanies a sample (or group of samples) as they are transferred from person to person. This form must be used for any samples collected for chemical or geotechnical analysis whether the analyses are performed on site or off site. One carbonless copy of the completed COC form is retained by the field crew, one copy is sent to the Project Manager (or designee), while the original is sent to the laboratory. The original (top, signed copy) of the COC form shall be placed inside a large Ziploc-type bag and taped inside the lid of the shipping cooler. If multiple coolers are sent but are included on one COC form, the COC form should be sent with the cooler containing vials for VOC analysis or the cooler with the air bill attached. The air bill should then state how many coolers are included with that shipment. An example of a Chain-of-Custody Record form is provided as Attachment C. Once the samples are received at the laboratory, the sample cooler and contents are checked and any problems are noted on the enclosed COC form (any discrepancies between the sample labels and COC form and any other problems that are noted are resolved through communication between the laboratory point-of-contact and the Tetra Tech NUS Project Manager). The COC form is signed and copied. The laboratory will retain the copy while the original becomes part of the samples' corresponding analytical data package.

5.3.1.4 Chain-of-Custody Seal

Attachment D is an example of a custody seal. The Custody seal is an adhesive-backed label. It is part of a chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field and sealed in coolers for transport to the laboratory. The COC seals are signed and dated by the sampler(s) and affixed across the lid and body of each cooler (front and back) containing environmental samples (see SOP SA-6.1). COC seals may be available from the laboratory; these seals may also be purchased from a supplier.

5.3.1.5 Geochemical Parameters Log Sheets

Field Analytical Log Sheets are used to record geochemical and/or natural attenuation field test results.

5.3.2 Hydrogeological and Geotechnical Forms

5.3.2.1 Groundwater Level Measurement Sheet

A Groundwater Level Measurement Sheet must be filled out for each round of water level measurements made at a site.

5.3.2.2 Data Sheet for Pumping Test

During the performance of a pumping test (or an in-situ hydraulic conductivity test), a large amount of data must be recorded, often within a short time period. The Pumping Test Data Sheet facilitates this task by standardizing the data collection format for the pumping well and observation wells, and allowing the time interval for collection to be laid out in advance.

5.3.2.3 Packer Test Report Form

A Packer Test Report Form must be completed for each well upon which a packer test is conducted.

5.3.2.4 Boring Log

During the progress of each boring, a log of the materials encountered, operation and driving of casing, and location of samples must be kept. The Summary Log of Boring, or Boring Log is used for this purpose and must be completed for each soil boring performed. In addition, if volatile organics are monitored on cores, samples, cuttings from the borehole, or breathing zone, (using a PID or FID), these readings must be entered on the boring log at the appropriate depth. The "Remarks" column can be used to subsequently enter the laboratory sample number, the concentration of key analytical results, or other pertinent information. This feature allows direct comparison of contaminant concentrations with soil characteristics.

5.3.2.5 Monitoring Well Construction Details Form

A Monitoring Well Construction Details Form must be completed for every monitoring well, piezometer, or temporary well point installed. This form contains specific information on length and type of well riser pipe and screen, backfill, filter pack, annular seal and grout characteristics, and surface seal characteristics. This information is important in evaluating the performance of the monitoring well, particularly in areas where water levels show temporal variation, or where there are multiple (immiscible) phases of contaminants. Depending on the type of monitoring well (in overburden or bedrock, stick-up or flush mount), different forms are used.

5.3.2.6 Test Pit Log

When a test pit or trench is constructed for investigative or sampling purposes, a Test Pit Log must be filled out by the responsible field geologist or sampling technician.

5.3.2.7 Miscellaneous Monitoring Well Forms

Monitoring Well Materials Certificate of Conformance should be used as the project directs to document all materials utilized during each monitoring well installation.

The Monitoring Well Development Record should be used as the project directs to document all well development activities.

5.3.2.8 Miscellaneous Field Forms - QA and Checklists

Container Sample and Inspection Sheet should be used as the project directs each time a container (drum, tank, etc.) is sampled and/or inspected.

QA Sample Log Sheet should be used at the project directs each time a QA sample is colleted, such as Rinsate Blank, Source Blank, etc.

Field Task Modification Request (FTMR) will be prepared for all deviations from the project planning documents. The FOL is responsible for initiating the FTMRs. Copies of all FTMRs will be maintained with the onsite planning documents and originals will be placed in the final evidence file.

The Field Project Daily Activities Check List and Field Project Pre-Mobilization Checklist should be used during both the planning and field effort to assure that all necessary tasks are planned for and completed. These two forms are not a requirement but a useful tool for most field work.

5.3.3 Equipment Calibration and Maintenance Form

The calibration or standardization of monitoring, measuring or test equipment is necessary to assure the proper operation and response of the equipment, to document the accuracy, precision or sensitivity of the measurement, and determine if correction should be applied to the readings. Some items of equipment require frequent calibration, others infrequent. Some are calibrated by the manufacturer, others by the user.

Each instrument requiring calibration has its own Equipment Calibration Log which documents that the manufacturer's instructions were followed for calibration of the equipment, including frequency and type of standard or calibration device. An Equipment Calibration Log must be maintained for each electronic measuring device used in the field; entries must be made for each day the equipment is used or in accordance with the manufacturer's recommendations.

5.4 Field Reports

The primary means of recording onsite activities is the site logbook. Other field notebooks may also be maintained. These logbooks and notebooks (and supporting forms) contain detailed information required for data interpretation or documentation, but are not easily useful for tracking and reporting of progress. Furthermore, the field logbook/notebooks remain onsite for extended periods of time and are thus not accessible for timely review by project management.

5.4.1 Daily Activities Report

To provide timely oversight of onsite contractors, Daily Activities Reports are completed and submitted as described below.

5.4.1.1 Description

The Daily Activities Report (DAR) documents the activities and progress for each day's field work. This report must be filled out on a daily basis whenever there are drilling, test pitting, well construction, or other related activities occurring which involve subcontractor personnel. These sheets summarize the work performed and form the basis of payment to subcontractors. The DAR form can be found on the TtNUS intranet site.

5.4.1.2 Responsibilities

It is the responsibility of the rig geologist to complete the DAR and obtain the driller's signature acknowledging that the times and quantities of material entered are correct.

5.4.1.3 Submittal and Approval

At the end of the shift, the rig geologist must submit the Daily Activities Report to the Field Operations Leader (FOL) for review and filing. The Daily Activities Report is not a formal report and thus requires no further approval. The DAR reports are retained by the FOL for use in preparing the site logbook and in preparing weekly status reports for submission to the Project Manager.

5.4.2 Weekly Status Reports

To facilitate timely review by project management, photocopies of logbook/notebook entries may be made for internal use.

It should be noted that in addition to summaries described herein, other summary reports may also be contractually required.

All Tetra Tech NUS field forms can be found on the company's intranet site at http://intranet.ttnus.com under Field Log Sheets.

6.0 LISTING OF TETRA TECH NUS FIELD FORMS FOUND ON THE TTNUS INTRANET SITE. HTTP://INTRANET.TTNUS.COM CLICK ON FIELD LOG SHEETS

Groundwater Sample Log Sheet
Surface Water Sample Log Sheet
Soil/Sediment Sample Log Sheet
Container Sample and Inspection Sheet
Geochemical Parameters (Natural Attenuation)
Groundwater Level Measurement Sheet
Pumping Test Data Sheet
Packer Test Report Form
Boring Log
Monitoring Well Construction Bedrock Flush Mount
Monitoring Well Construction Bedrock Open Hole
Monitoring Well Construction Bedrock Stick Up
Monitoring Well Construction Confining Layer
Monitoring Well Construction Overburden Flush Mount
Monitoring Well Construction Overburden Stick Up
Test Pit Log
Monitoring Well Materials Certificate of Conformance
Monitoring Well Development Record

Daily Activities Record
Field Task Modification Request
Hydraulic Conductivity Test Data Sheet
Low Flow Purge Data Sheet
QA Sample Log Sheet
Equipment Calibration Log
Field Project Daily Activities Checklist
Field Project Pre-Mobilization Checklist

ATTACHMENT A
TYPICAL SITE LOGBOOK ENTRY

START TIME: ______________________ DATE: ______________________

SITE LEADER: ____
PERSONNEL:

TtNUS	DRILLER	SITE VISITORS
______	______	______
______	______	______
______	______	______

WEATHER: Clear, 68°F, 2-5 mph wind from SE

ACTIVITIES:

1. Steam jenney and fire hoses were set up.
2. Drilling activities at well ____ resumes. Rig geologist was ______________. See Geologist's Notebook, No. 1, page 29-30, for details of drilling activity. Sample No. 123-21-S4 collected; see sample logbook, page 42. Drilling activities completed at 11:50 and a 4-inch stainless steel well installed. See Geologist's Notebook, No. 1, page 31, and well construction details for well ______.
3. Drilling rig No. 2 steam-cleaned at decontamination pit. Then set up at location of well _______.
4. Well ______ drilled. Rig geologist was ___________________. See Geologist's Notebook, No. 2, page ____ for details of drilling activities. Sample numbers 123-22-S1, 123-22-S2, and 123-22-S3 collected; see sample logbook, pages 43, 44, and 45.
5. Well _____ was developed. Seven 55-gallon drums were filled in the flushing stage. The well was then pumped using the pitcher pump for 1 hour. At the end of the hour, water pumped from well was "sand free."
6. EPA remedial project manger arrives on site at 14:25 hours.
7. Large dump truck arrives at 14:45 and is steam-cleaned. Backhoe and dump truck set up over test pit _________.
8. Test pit _______ dug with cuttings placed in dump truck. Rig geologist was _______________. See Geologist's Notebook, No. 1, page 32, for details of test pit activities. Test pit subsequently filled. No samples taken for chemical analysis. Due to shallow groundwater table, filling in of test pit ___ resulted in a very soft and wet area. A mound was developed and the area roped off.
9. Express carrier picked up samples (see Sample Logbook, pages 42 through 45) at 17:50 hours. Site activities terminated at 18:22 hours. All personnel off site, gate locked.

____

Field Operations Leader

ATTACHMENT B

Tetra Tech NUS, Inc. 661 Andersen Drive Pittsburgh, 15220 (412)921-7090	**Project:** **Site:** **Location:**	
Sample No:		**Matrix:**
Date:	**Time:**	**Preserve:**
Analysis:		
Sampled by:		**Laboratory:**

ATTACHMENT C

TETRA TECH NUS, INC. CHAIN OF CUSTODY | NUMBER 3413 | PAGE ___ OF ____

PROJECT NO:	FACILITY:	PROJECT MANAGER	PHONE NUMBER	LABORATORY NAME AND CONTACT:
SAMPLERS (SIGNATURE)		FIELD OPERATIONS LEADER	PHONE NUMBER	ADDRESS
		CARRIER/WAYBILL NUMBER		CITY, STATE

STANDARD TAT ☐
RUSH TAT ☐
☐ 24 hr. ☐ 48 hr. ☐ 72 hr. ☐ 7 day ☐ 14 day

CONTAINER TYPE PLASTIC (P) or GLASS (G)

PRESERVATIVE USED

DATE YEAR	TIME	SAMPLE ID	LOCATION ID	TOP DEPTH (FT)	BOTTOM DEPTH (FT)	MATRIX (GW, SO, SW, SD, QC, ETC.)	COLLECTION METHOD GRAP (G) COMP (C)	No. OF CONTAINERS	TYPE OF ANALYSIS								COMMENTS

1. RELINQUISHED BY	DATE	TIME	1. RECEIVED BY	DATE	TIME
2. RELINQUISHED BY	DATE	TIME	2. RECEIVED BY	DATE	TIME
3. RELINQUISHED BY	DATE	TIME	3. RECEIVED BY	DATE	TIME

COMMENTS

DISTRIBUTION: WHITE (ACCOMPANIES SAMPLE) YELLOW (FIELD COPY) PINK (FILE COPY)

4/02R
FORM NO. TtNUS-001

ATTACHMENT D

CHAIN-OF-CUSTODY SEAL

Signature ______________	**CUSTODY SEAL**
Date ______________	______________ **Date**
CUSTODY SEAL	______________ **Signature**

Subject: GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING

TABLE OF CONTENTS

ATTACHMENTS

1.0 PURPOSE

The purpose of this procedure is to provide general reference information regarding the sampling of groundwater wells.

2.0 SCOPE

This procedure provides information on proper sampling equipment, onsite water quality testing, and techniques for groundwater sampling. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling techniques. The techniques described shall be followed whenever applicable, noting that site-specific conditions or project-specific plans may require modifications to methodology.

3.0 GLOSSARY

Conductivity – Conductivity is a numerical expression of the ability of an aqueous solution to carry an electric current. This ability depends on the presence of ions, their total concentration, mobility, valence, and relative concentrations, and on temperature of measure. Conductivity is highly dependent on temperature and should be reported at a particular temperature, i.e., 20.2 mS/cm at 14°C.

Dissolved Oxygen (DO) – DO levels in natural and wastewater depend on the physical, chemical, and biochemical activities in the water sample.

Oxidation-Reduction Potential (ORP) - A measure of the activity ratio of oxidizing and reducing species as determined by the electromotive force developed by a noble metal electrode, immersed in water, as referenced against a standard hydrogen electrode.

pH - The negative logarithm (base 10) of the hydrogen ion activity. The hydrogen ion activity is related to the hydrogen ion concentration, and, in a relatively weak solution, the two are nearly equal. Thus, for all practical purposes, pH is a measure of the hydrogen ion concentration.

pH Paper - Indicator paper that turns different colors depending on the pH of the solution to which it is exposed. Comparison with color standards supplied by the manufacturer will then give an indication of the solution's pH.

Salinity – The measurement of dissolved salts in a given mass of solution. Note: most field meters determined salinity automatically from conductivity and temperature. The displayed value will be displayed in either parts per thousand (ppt) or % (e.g., 35 ppt will equal 3.5%).

Turbidity – Turbidity in water is caused by suspended matter, such as clay, silt, fine organic and inorganic matter. Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in a straight line through the sample.

4.0 RESPONSIBILITIES

Project Hydrogeologist - Responsible for selecting and detailing the specific groundwater sampling techniques, onsite water quality testing (type, frequency, and location), and equipment to be used, and providing detailed input in this regard to the project plan documents. The project hydrogeologist is also responsible for properly briefing and overseeing the performance of the site sampling personnel.

Project Geologist/Field Sample Technician - is primarily responsible for the proper acquisition of the groundwater samples. He/she is also responsible for the actual analyses of onsite water quality samples, as well as instrument calibration, care, and maintenance. When appropriate, such responsibilities may be performed by other qualified personnel (e.g., field technicians).

5.0 PROCEDURES

5.1 General

To be useful and accurate, a groundwater sample must be representative of the particular zone of the water being sampled. The physical, chemical, and bacteriological integrity of the sample must be maintained from the time of sampling to the time of analysis in order to keep any changes in water quality parameters to a minimum.

Methods for withdrawing samples from completed wells include the use of pumps, compressed air, bailers, and various types of samplers. The primary considerations in obtaining a representative sample of the groundwater are to avoid collection of stagnant (standing) water in the well and to avoid physical or chemical alteration of the water due to sampling techniques. In a non-pumping well, there will be little or no vertical mixing of water in the well pipe or casing, and stratification will occur. The well water in the screened section will mix with the groundwater due to normal flow patterns, but the well water above the screened section will remain isolated and become stagnant. To safeguard against collecting non-representative stagnant water in a sample, the following approach shall be followed prior to sample acquisition:

1. All monitoring wells shall be purged prior to obtaining a sample. Evacuation of three to five volumes is recommended prior to sampling. In a high-yielding groundwater formation and where there is no stagnant water in the well above the screened section, extensive evacuation prior to sample withdrawal is not as critical.

2. For wells that can be purged dry, the well shall be evacuated and allowed to recover to 75% full capacity prior to sample acquisition. If the recovery rate is fairly rapid, evacuation of more than one volume of water is required.

3. For high-yielding monitoring wells which cannot be evacuated to dryness, there is no absolute safeguard against contaminating the sample with stagnant water. One of the following techniques shall be used to minimize this possibility:

    - A submersible pump or the intake line of a surface pump or bailer shall be placed just below the water surface when removing the stagnant water and lowered as the water level drops. Three to five volumes of water shall be removed to provide reasonable assurance that all stagnant water has been evacuated. Once this is accomplished, a bailer or other approved device may be used to collect the sample for analysis.

    - The intake line of the sampling pump (or the submersible pump itself) unless otherwise directed shall be placed near the center of the screened section, and approximately one casing volume of water shall be pumped from the well at a low purge rate, equal to the well's recovery rate (low flow sampling).

Stratification of contaminants may exist in the aquifer. Concentration gradients as a result of mixing and dispersion processes, layers of variable permeability, and the presence of separate-phase product (i.e., floating hydrocarbons) may cause stratification. Excessive pumping or improper sampling methods can dilute or increase the contaminant concentrations in the recovered sample compared to what is representative of the integrated water column as it naturally occurs at that point, thus the result is the collection of a non-representative sample.

5.2 Sampling, Monitoring, and Evacuation Equipment

Sample containers shall conform with the guidelines expressed in SOP SA-6.1.

The following equipment shall be on hand when sampling groundwater wells (reference SOPs SA-6.1 and SA-7.1):

- Sample packaging and shipping equipment - Coolers for sample shipping and cooling, chemical preservatives, appropriate sampling containers and filler, ice, labels and chain-of-custody documents.

- Field tools and instrumentation - Multi-parameters water quality meter capable of measuring ORP, pH, temperature, DO, specific conductance, turbidity and salinity or individual meters (as applicable), pH paper, camera and film (if appropriate), appropriate keys (for locked wells), water level indicator.

- Pumps

  - Shallow-well pumps: Centrifugal, bladder, suction, or peristaltic pumps with droplines, air-lift apparatus (compressor and tubing) where applicable.

  - Deep-well pumps: Submersible pump and electrical power-generating unit, or bladder pumps where applicable.

- Other sampling equipment - Bailers and inert line with tripod-pulley assembly (if necessary).

- Pails - Plastic, graduated.

- Decontamination solutions - Deionized water, potable water, laboratory detergents, 10% nitric acid solution (as required), and analytical-grade solvent (e.g., pesticide-grade isopropanol), as required.

Ideally, sample withdrawal equipment shall be completely inert, economical, easily cleaned, cleaned prior to use, reusable, able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for well purging and sample collection.

5.3 Calculations of Well Volume

To insure that the proper volume of water has been removed from the well prior to sampling it is first necessary to know the volume of standing water in the well pipe. This volume can be easily calculated by the following method. Calculations shall be entered in the site logbook or field notebook or on a sample log sheet form (see SOP SA-6.3):

- Obtain all available information on well construction (location, casing, screens, etc.).

- Determine well or inner casing diameter.

- Measure and record static water level (depth below ground level or top of casing reference point).

- Determine depth of well by sounding using a clean, decontaminated, weighted tape measure.

- Calculate number of linear feet of static water (total depth or length of well pipe minus the depth to static water level).

- Calculate one static well volume in gallons $V = (0.163)(T)(r^2)$ 1

where: V = Static volume of well in gallons.
T= Thickness of water table in the well measured in feet (i.e., linear feet of static water).
r = Inside radius of well casing in inches.
0.163 = A constant conversion factor which compensates for the conversion of the casing radius from inches to feet, the conversion of cubic feet to gallons, and pi.

- Per evacuation volumes discussed above, determine the minimum amount to be evacuated before sampling.

5.4 Evacuation of Static Water (Purging)

5.4.1 General

The amount of purging a well shall receive prior to sample collection will depend on the intent of the monitoring program and the hydrogeologic conditions. Programs to determine overall quality of water resources may require long pumping periods to obtain a sample that is representative of a large volume of that aquifer. The pumped volume may be specified prior to sampling so that the sample can be a composite of a known volume of the aquifer. Alternately the well can be pumped until the parameters such as temperature, specific conductance, pH, and turbidity (as applicable), have stabilized. Onsite measurements of these parameters shall be recorded in the site logbook, field notebook, or on standardized data sheets.

5.4.2 Evacuation Devices

The following discussion is limited to those devices commonly used at hazardous waste sites. Attachment A provides guidance on the proper evacuation device to use for given sampling situations. Note that all of these techniques involve equipment which is portable and readily available.

Bailers

Bailers are the simplest evacuation devices used and have many advantages. They generally consist of a length of pipe with a sealed bottom (bucket-type bailer) or, as is more useful and favored, with a ball check-valve at the bottom. An inert line is used to lower the bailer and retrieve the sample.

Advantages of bailers include:

- Few limitations on size and materials used for bailers.
- No external power source needed.
- Bailers are inexpensive, and can be dedicated and hung in a well to reduce the chances of cross-contamination.
- Bailers are relatively easy to decontaminate.

Limitations on the use of bailers include the following:

- It is time consuming to remove stagnant water using a bailer.
- Transfer of sample may cause aeration.
- Use of bailers is physically demanding, especially in warm temperatures at protection levels above Level D.

Suction Pumps

There are many different types of inexpensive suction pumps including centrifugal, diaphragm, and peristaltic pumps. Centrifugal and diaphragm pumps can be used for well evacuation at a fast pumping rate and for sampling at a low pumping rate. The peristaltic pump is a low volume pump that uses rollers to squeeze a flexible tubing, thereby creating suction. This tubing can be dedicated to a well to prevent cross contamination.

These pumps are all portable, inexpensive and readily available. However, because they are based on suction, their use is restricted to areas with water levels within 20 to 25 feet of the ground surface. A significant limitation is that the vacuum created by these pumps can cause significant loss of dissolved gases and volatile organics.

Air-Lift Samplers

This group of pump samplers uses gas pressure either in the annulus of the well or in a venturi to force the water up a sampling tube. These pumps are also relatively inexpensive. Air (or gas)-lift samplers are more suitable for well development than for sampling because the samples may be aerated, leading to pH changes and subsequent trace metal precipitation, or loss of volatile organics.

Submersible Pumps

Submersible pumps take in water and push the sample up a sample tube to the surface. The power sources for these samplers may be compressed gas or electricity. The operation principles vary and the displacement of the sample can be by an inflatable bladder, sliding piston, gas bubble, or impeller. Pumps are available for 2-inch-diameter wells and larger. These pumps can lift water from considerable depths (several hundred feet).

Limitations of this class of pumps include:

- They may have low delivery rates.
- Many models of these pumps are expensive.
- Compressed gas or electric power is needed.
- Sediment in water may cause clogging of the valves or eroding the impellers with some of these pumps.
- Decontamination of internal components can be difficult and time-consuming.

5.5 Onsite Water Quality Testing

This section describes the procedures and equipment required to measure the following parameters of an aqueous sample in the field:

- pH
- Specific Conductance
- Temperature
- Dissolved Oxygen (DO)
- Oxidation-Reduction Potential (ORP)

- Turbidity
- Salinity

This section is applicable for use in an onsite groundwater quality monitoring program to be conducted at a hazardous or nonhazardous site. The procedures and equipment described are applicable to groundwater samples and are not, in general, subject to solution interferences from color, turbidity, and colloidal material or suspended matter.

This section provides general information for measuring the parameters listed above with instruments and techniques in common use. Since instruments from different manufacturers may vary, review of the manufacturer's literature pertaining to the use of a specific instrument is required before use. Most meters used to measure field parameters require calibration on a daily basis. Refer to SOP 6.3 for example equipment calibration log.

5.5.1 Measurement of pH

5.5.1.1 General

Measurement of pH is one of the most important and frequently used tests in water chemistry. Practically every phase of water supply and wastewater treatment such as acid-base neutralization, water softening, and corrosion control is pH dependent. Likewise, the pH of leachate can be correlated with other chemical analyses to determine the probable source of contamination. It is therefore important that reasonably accurate pH measurements be taken.

Two methods are given for pH measurement: the pH meter and pH indicator paper. The indicator paper is used when only a rough estimate of the pH is required, and the pH meter when a more accurate measurement is needed. The response of a pH meter can be affected to a slight degree by high levels of colloidal or suspended solids, but the effect is usually small and generally of little significance. Consequently, specific methods to overcome this interference are not described. The response of pH paper is unaffected by solution interferences from color, turbidity, colloidal or suspended materials unless extremely high levels capable of coating or masking the paper are encountered. In such cases, use of a pH meter is recommended.

5.5.1.2 Principles of Equipment Operation

Use of pH papers for pH measurement relies on a chemical reaction caused by the acidity or alkalinity of the solution created by the addition of the water sample reacting with the indicator compound on the paper. Various types of pH papers are available, including litmus (for general acidity or alkalinity determination) and specific pH range hydrion paper.

Use of a pH meter relies on the same principle as other ion-specific electrodes. Measurement relies on establishment of a potential difference across a glass or other type of membrane in response to (in this instance, hydrogen) ion concentration across that membrane. The membrane is conductive to ionic species and, in combination with a standard or reference electrode, a potential difference proportional to the ion concentration is generated and measured.

5.5.1.3 Equipment

The following equipment is needed for taking pH measurements:

- Stand-alone portable pH meter, or combination meter (e.g., Horiba U-10), or combination meters equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).

- Combination electrode with polymer body to fit the above meter (alternately a pH electrode and a reference electrode can be used if the pH meter is equipped with suitable electrode inputs).

- Buffer solutions, as specified by the manufacturer.

- pH indicator paper, to cover the pH range 2 through 12.

- Manufacturer's operation manual.

5.5.1.4 Measurement Techniques for Field Determination of pH

pH Meter

The following procedure is used for measuring pH with a pH meter (meter standardization is according to manufacturer's instructions):

- Inspect the instrument and batteries prior to initiation of the field effort.

- Check the integrity of the buffer solutions used for field calibration. Buffer solutions need to be changed often as a result of degradation upon exposure to the atmosphere.

- If applicable, make sure all electrolyte solutions within the electrode(s) are at their proper levels and that no air bubbles are present within the electrode(s).

- Calibrate on a daily use basis (or as recommended by manufacturer) following manufacturer's instructions. Record calibration data on an equipment calibration log sheet.

- Immerse the electrode(s) in the sample. Stabilization may take several seconds to minutes. If the pH continues to drift, the sample temperature may not be stable, a physical reaction (e.g., degassing) may be taking place in the sample, or the meter or electrode may be malfunctioning. This must be clearly noted in the logbook.

- Read and record the pH of the sample. pH shall be recorded to the nearest 0.01 pH unit. Also record the sample temperature.

- Rinse the electrode(s) with deionized water.

- Store the electrode(s) in an appropriate manner when not in use.

Any visual observation of conditions which may interfere with pH measurement, such as oily materials, or turbidity, shall be noted.

pH Paper

Use of pH paper is very simple and requires no sample preparation, standardization, etc. pH paper is available in several ranges, including wide-range (indicating approximately pH 1 to 12), mid-range (approximately pH 0 to 6, 6 to 9, 8 to 14) and narrow-range (many available, with ranges as narrow as 1.5 pH units). The appropriate range of pH paper shall be selected. If the pH is unknown the investigation shall start with wide-range paper and proceed with successively narrower range paper until the sample pH is adequately determined.

5.5.2 Measurement of Specific Conductance

5.5.2.1 General

Conductance provides a measure of dissolved ionic species in water and can be used to identify the direction and extent of migration of contaminants in groundwater or surface water. It can also be used as a measure of subsurface biodegradation or to indicate alternate sources of groundwater contamination.

Conductivity is a numerical expression of the ability of a water sample to carry an electric current. This value depends on the total concentration of the ionized substances dissolved in the water and the temperature at which the measurement is made. The mobility of each of the various dissolved ions, their valences, and their actual and relative concentrations affect conductivity.

It is important to obtain a specific conductance measurement soon after taking a sample, since temperature changes, precipitation reactions, and absorption of carbon dioxide from the air all affect the specific conductance. Most conductivity meters in use today display specific conductance (SC); units of milliSiemens per centimeter, which is the conductivity normalized to temperature @ 25°C. This format (SC) is the required units recorded on the groundwater sample log field form (Attachment B).

5.5.2.2 Principles of Equipment Operation

An aqueous system containing ions will conduct an electric current. In a direct-current field, the positive ions migrate toward the negative electrode, while the negatively charged ions migrate toward the positive electrode. Most inorganic acids, bases and salts (such as hydrochloric acid, sodium carbonate, or sodium chloride, respectively) are relatively good conductors. Conversely, organic compounds such as sucrose or benzene, which do not dissociate in aqueous solution, conduct a current very poorly, if at all.

A conductance cell and a Wheatstone Bridge (for the measurement of potential difference) may be used for measurement of electrical resistance. The ratio of current applied to voltage across the cell may also be used as a measure of conductance. The core element of the apparatus is the conductivity cell containing the solution of interest. Depending on ionic strength of the aqueous solution to be tested, a potential difference is developed across the cell which can be converted directly or indirectly (depending on instrument type) to a measurement of specific conductance.

5.5.2.3 Equipment

The following equipment is needed for taking specific conductance (SC) measurements:

- Stand alone portable conductivity meter, or combination meter (e.g., Horiba U-10), or combination meters equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Calibration solution, as specified by the manufacturer.
- Manufacturer's operation manual.

A variety of conductivity meters are available which may also be used to monitor salinity and temperature. Probe types and cable lengths vary, so equipment must be obtained to meet the specific requirement of the sampling program.

5.5.2.4 Measurement Techniques for Specific Conductance

The steps involved in taking specific conductance measurements are listed below (standardization is according to manufacturer's instructions):

- Check batteries and calibrate instrument before going into the field.
- Calibrate on a daily use basis (or as recommended by manufacturer), according to the manufacturer's instructions and record all pertinent information on an equipment calibration log sheet. Potassium chloride solutions with a SC closest to the values expected in the field shall be used for calibration.
- Rinse the cell with one or more portions of the sample to be tested or with deionized water.
- Immerse the electrode in the sample and measure the conductivity.
- Read and record the results in a field logbook or sample log sheet.
- Rinse the electrode with deionized water.

If the specific conductance measurements become erratic, recalibrate the instrument and see the manufacturer's instructions for details.

5.5.3 Measurement of Temperature

5.5.3.1 General

In combination with other parameters, temperature can be a useful indicator of the likelihood of biological action in a water sample. It can also be used to trace the flow direction of contaminated groundwater. Temperature measurements shall be taken in-situ, or as quickly as possible in the field. Collected water samples may rapidly equilibrate with the temperature of their surroundings.

5.5.3.2 Equipment

Temperature measurements may be taken with alcohol-toluene, mercury filled, dial-type thermometers or combination meters equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).. In addition, various meters such as specific conductance or dissolved oxygen meters, which have temperature measurement capabilities, may also be used. Using such instrumentation along with suitable probes and cables, in-situ measurements of temperature at great depths can be performed.

5.5.3.3 Measurement Techniques for Water Temperature

If a thermometer is used to determine the temperature for a water sample:

- Immerse the thermometer in the sample until temperature equilibrium is obtained (1-3 minutes). To avoid the possibility of cross-contamination, the thermometer shall not be inserted into samples which will undergo subsequent chemical analysis.
- Record values in a field logbook or sample log sheet.

If a temperature meter or probe is used, the instrument shall be calibrated according to manufacturer's recommendations.

5.5.4 Measurement of Dissolved Oxygen

5.5.4.1 General

Dissolved oxygen (DO) levels in natural water and wastewater depend on the physical, chemical and biochemical activities in the water body. Conversely, the growth of many aquatic organisms as well as the rate of corrosivity, are dependent on the dissolved oxygen concentration. Thus, analysis for dissolved oxygen is a key test in water pollution and waste treatment process control. If at all possible, DO measurements shall be taken in-situ, since concentration may show a large change in a short time if the sample is not adequately preserved.

The monitoring method discussed herein is limited to the use of dissolved oxygen meters only. Chemical methods of analysis (i.e., Winkler methods) are available, but require more equipment and greater sample manipulation. Furthermore, DO meters, using a membrane electrode, are suitable for highly polluted waters, because the probe is completely submersible, and is not susceptible to interference caused by color, turbidity, colloidal material or suspended matter.

5.5.4.2 Principles of Equipment Operation

Dissolved oxygen probes are normally electrochemical cells that have two solid metal electrodes of different nobility immersed in an electrolyte. The electrolyte is retained by an oxygen-permeable membrane. The metal of highest nobility (the cathode) is positioned at the membrane. When a suitable potential exists between the two metals, reduction of oxygen to hydroxide ion (OH^-) occurs at the cathode surface. An electrical current is developed that is directly proportional to the rate of arrival of oxygen molecules at the cathode.

Since the current produced in the probe is directly proportional to the rate of arrival of oxygen at the cathode, it is important that a fresh supply of sample always be in contact with the membrane. Otherwise, the oxygen in the aqueous layer along the membrane is quickly depleted and false low readings are obtained. It is therefore necessary to stir the sample (or the probe) constantly to maintain fresh solution near the membrane interface. Stirring, however, shall not be so vigorous that additional oxygen is introduced through the air-water interface at the sample surface. To avoid this possibility, some probes are equipped with stirrers to agitate the solution near the probe, while leaving the surface of the solution undisturbed.

Dissolved oxygen probes are relatively unaffected by interferences. Interferences that can occur are reactions with oxidizing gases (such as chlorine) or with gases such as hydrogen sulfide, which are not easily depolarized from the indicating electrode. If a gaseous interference is suspected, it shall be noted in the field log book and checked if possible. Temperature variations can also cause interference because probes exhibit temperature sensitivity. Automatic temperature compensation is normally provided by the manufacturer.

5.5.4.3 Equipment

The following equipment is needed to measure dissolved oxygen concentration:

- Stand alone portable dissolved oxygen meter, or combination meter (e.g., Horiba U-10), or combination meters equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Sufficient cable to allow the probe to contact the sample.
- Manufacturer's operation manual.

5.5.4.4 Measurement Techniques for Dissolved Oxygen Determination

Probes differ as to specifics of use. Follow the manufacturer's instructions to obtain an accurate reading. The following general steps shall be used to measure the dissolved oxygen concentration:

- The equipment shall be calibrated and have its batteries checked before going to the field.
- The probe shall be conditioned in a water sample for as long a period as practical before use in the field. Long periods of dry storage followed by short periods of use in the field may result in inaccurate readings.
- The instrument shall be calibrated in the field according to manufacturer's recommendations or in a freshly air-saturated water sample of known temperature.
- Record all pertinent information on an equipment calibration sheet.
- Rinse the probe with deionized water.
- Immerse the probe in the sample. Be sure to provide for sufficient flow past the membrane by stirring the sample. Probes without stirrers placed in wells can be moved up and down.
- Record the dissolved oxygen content and temperature of the sample in a field logbook or sample log sheet.
- Rinse the probe with deionized water.
- Recalibrate the probe when the membrane is replaced, or as needed. Follow the manufacturer's instructions.

Note that in-situ placement of the probe is preferable, since sample handling is not involved. This however, may not always be practical.

Special care shall be taken during sample collection to avoid turbulence which can lead to increased oxygen solubilization and positive test interferences.

5.5.5 Measurement of Oxidation-Reduction Potential

5.5.5.1 General

The oxidation-reduction potential (ORP) provides a measure of the tendency of organic or inorganic compounds to exist in an oxidized state. The ORP parameter therefore provides evidence of the likelihood of anaerobic degradation of biodegradable organics or the ratio of activities of oxidized to reduced species in the sample.

5.5.5.2 Principles of Equipment Operation

When an inert metal electrode, such as platinum, is immersed in a solution, a potential is developed at that electrode depending on the ions present in the solution. If a reference electrode is placed in the same solution, an ORP electrode pair is established. This electrode pair allows the potential difference between the two electrodes to be measured and is dependent on the concentration of the ions in solution. By this measurement, the ability to oxidize or reduce species in solution may be determined. Supplemental measurements, such as dissolved oxygen, may be correlated with ORP to provide a knowledge of the quality of the solution, water, or wastewater.

5.5.5.3 Equipment

The following equipment is needed for measuring the oxidation-reduction potential of a solution:

- Combination meters with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Reference solution as specified by the manufacturer.
- Manufacturer's operation manual.

5.5.5.4 Measurement Techniques for Oxidation-Reduction Potential

The following procedure is used for measuring oxidation-reduction potential:

- The equipment shall be checked using the manufacturer's recommended reference solution and have its batteries checked before going to the field.

- Thoroughly rinse the electrode with deionized water.

- If the probe does not respond properly to the recommended reference solution, then verify the sensitivity of the electrodes by noting the change in millivolt reading when the pH of a test solution is altered. The ORP will increase when the pH of a test solution decreases, and the ORP will decrease if the test solution pH is increased. Place the sample in a clean container and agitate the sample. Insert the electrodes and note the ORP drops sharply when the caustic is added (i.e., pH is raised) thus indicating the electrodes are sensitive and operating properly. If the ORP increases sharply when the caustic is added, the polarity is reversed and must be corrected in accordance with the manufacturer's instructions or the probe should be replaced.

- Record all pertinent information on an equipment calibration log sheet.

5.5.6 Measurement of Turbidity

5.5.6.1 General

Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in a straight line through the sample. Turbidity in water is caused by suspended matter, such as clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds, and microscopic organisms, including plankton.

It is important to obtain a turbidity reading immediately after taking a sample, since irreversible changes in turbidity may occur if the sample is stored too long.

5.5.6.2 Principles of Equipment Operation

Turbidity is measured by the Nephelometric Method. This method is based on a comparison of the intensity of light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension under the same conditions. The higher the scattered light intensity, the higher the turbidity.

Formazin polymer is used as the reference turbidity standard suspension because of its ease of preparation combined with a higher reproducibility of its light-scattering properties than clay or turbid natural water. The turbidity of a specified concentration of formazin suspension is defined as 40 nephelometric units. This same suspension has an approximate turbidity of 40 Jackson units when measured on the candle turbidmeter. Therefore, nephelometric turbidity units (NTU) based on the formazin preparation will approximate units derived from the candle turbidimeter but will not be identical to them.

5.5.6.3 Equipment

The following equipment is needed for turbidity measurement:

- Light meter (e.g., LaMotte 2020) which calibrates easily using test cells with standards of 0.0 NTUs, and 10 NTUs, or combination meter (e.g., Horiba U-10), or combination meter equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Calibration solution, as specified by the manufacturer.
- Manufacturer's operation manual.

5.5.6.4 Measurement Techniques for Turbidity

The steps involved in taking turbidity measurements utilizing an electrode (e) or light meter (l) are listed below (standardization is according to manufacturer's instructions):

- Check batteries and calibrate instrument before going into the field.
- Check the expiration date (etc.) of the solutions used for field calibration.
- Calibrate on a daily use basis, according to the manufacturer's instructions and record all pertinent information on an equipment calibration log sheet.
- Rinse the electrode with one or more portions of the sample to be tested or with deionized water (applies to "e").
- Fill the light meters glass test cell with ~5 ml of sample, screw on cap, wipe off glass, place test cell in light meter and close the lid (applies to "l").
- Immerse the electrode in the sample and measure the turbidity (applies to "e").
- The reading must be taken immediately as suspended solids will settle over time resulting in a lower, inaccurate turbidity reading.
- Read and record the results in a field logbook or sample log sheet. Include a physical description of the sample, including color, qualitative estimate of turbidity, etc.
- Rinse the electrode or test cell with deionized water.

5.5.7 Measurement of Salinity

5.5.7.1 General

Salinity is a unitless property of industrial and natural waters. It is the measurement of dissolved salts in a given mass of solution. Note: Most field meters determined salinity automatically from conductivity and temperature. The displayed value will be displayed in either parts per thousand (ppt) or % (e.g., 35 ppt will equal 3.5%).

5.5.7.2 Principles of Equipment Operation

Salinity is determined automatically from the meter's conductivity and temperature readings according to algorithms (found in *Standard methods for the Examination of Water and Wastewater*). Depending on the meter, the results are displayed in either ppt or %. The salinity measurements are carried out in reference to the conductivity of standard seawater (*corrected to S = 35*).

5.5.7.3 Equipment

The following equipment is needed for Salinity measurements:

- Multi-parameter water quality meter capable of measuring conductive, temperature and converting them to salinity (e.g., Horiba U-10 or YSI 600 series).
- Calibration Solution, as specified by the manufacturer.
- Manufacturer's operation manual.

5.5.7.4 Measurement Techniques for Salinity

The steps involved in taking Salinity measurements are listed below (standardization is according to manufacturer's instructions):

- Check batteries and calibrate before going into the field.
- Check the expiration date (etc.) of the solutions used for field calibration.
- Calibrate on a daily use basis, according to the manufacturer's instructions and record all pertinent information on an equipment calibration log sheet.
- Rinse the cell with the sample to be tested.
- Immerse the multi-probe in the sample and measure the salinity. Read and record the results in a field logbook or sample log sheet.
- Rinse the probes with deionized water.

5.6 Sampling

5.6.1 Sampling Plan

The sampling approach consisting of the following, shall be developed as part of the project plan documents which are approved prior to beginning work in the field:

- Background and objectives of sampling.
- Brief description of area and waste characterization.
- Identification of sampling locations, with map or sketch, and applicable well construction data (well size, depth, screened interval, reference elevation).

- Intended number, sequence volumes, and types of samples. If the relative degrees of contamination between wells is unknown or insignificant, a sampling sequence which facilitates sampling logistics may be followed. Where some wells are known or strongly suspected of being highly contaminated, these shall be sampled last to reduce the risk of cross-contamination between wells as a result of the sampling procedures.
- Sample preservation requirements.
- Work schedule.
- List of team members.
- List of observers and contacts.
- Other information, such as the necessity for a warrant or permission of entry, requirement for split samples, access problems, location of keys, etc.

5.6.2 Sampling Methods

The collection of a groundwater sample consists of the following steps:

1. The site Health & Safety Officer (or designee) will first open the well cap and use volatile organic detection equipment (PID or FID) on the escaping gases at the well head to determine the need for respiratory protection.
2. When proper respiratory protection has been donned, sound the well for total depth and water level (using clean equipment) and record these data on a groundwater sampling log sheet (see Attachment B); then calculate the fluid volume in the well pipe (as previously described in this SOP).
3. Calculate well volume to be removed as stated in Section 5.3.
4. Select the appropriate purging equipment (see Attachment A). If an electric submersible pump with packer is chosen, go to Step 10.
5. Lower the purging equipment or intake into the well to a short distance below the water level and begin water removal. Collect the purged water and dispose of it in an acceptable manner (as applicable). Lower the purging device, as required, to maintain submergence.
6. Measure the rate of discharge frequently. A graduated bucket or cylinder and stopwatch are most commonly used.
7. Observe the peristaltic pump intake for degassing "bubbles." If bubbles are abundant and the intake is fully submerged, this pump is not suitable for collecting samples for volatile organics.
8. Purge a minimum of three to five casing volumes before sampling. In low-permeability strata (i.e., if the well is pumped to dryness), one volume will suffice. Purged water shall be collected in a designated container and disposed in an acceptable manner.
9. If sampling using a pump, lower the pump intake to midscreen (or the middle of the open section in uncased wells) and collect the sample. If sampling with a bailer, lower the bailer to just below the water surface.

10. (For pump and packer assembly only). Lower the assembly into the well so that the packer is positioned just above the screen or open section. Inflate the packer. Purge a volume equal to at least twice the screened interval (or unscreened open section volume below the packer) before sampling. Packers shall always be tested in a casing section above ground to determine proper inflation pressures for good sealing.

11. In the event that recovery time of the well is very slow (e.g., 24 hours or greater), sample collection can be delayed until the following day. If the well has been purged early in the morning, sufficient water may be standing in the well by the day's end to permit sample collection. If the well is incapable of producing a sufficient volume of sample at any time, take the largest quantity available and record this occurrence in the site logbook.

12. Fill sample containers (preserve and label as described in SOP SA-6.1).

13. Replace the well cap and lock as appropriate. Make sure the well is readily identifiable as the source of the samples.

14. Process sample containers as described in SOP SA-6.1.

15. Decontaminate equipment as described in SOP SA-7.1.

5.7 Low Flow Purging and Sampling

5.7.1 Scope & Application

Low flow purging and sampling techniques are sometimes required for groundwater sampling activities. The purpose of low flow purging and sampling is to collect groundwater samples that contain "representative" amounts of mobile organic and inorganic constituents in the vicinity of the selected open well interval, at or near natural flow conditions. The minimum stress procedure emphasizes negligible water level drawdown and low pumping rates in order to collect samples with minimal alterations in water chemistry. This procedure is designed primarily to be used in wells with a casing diameter of 1 inch or more and a saturated screen, or open interval, length of ten feet or less. Samples obtained are suitable for analyses of common types of groundwater contaminants (volatile and semi-volatile organic compounds, pesticides, PCBs, metals and other inorganic ions [cyanide, chloride, sulfate, etc.]). This procedure is not designed to collect non-aqueous phase liquids samples from wells containing light or dense non-aqueous phase liquids (LNAPLs or DNAPLs), using the low flow pumps.

The procedure is flexible for various well construction types and groundwater yields. The goal of the procedure is to obtain a turbidity level of less than 10 NTU and to achieve a water level drawdown of less than 0.3 feet during purging and sampling. If these goals cannot be achieved, sample collection can take place provided the remaining criteria in this procedure are met.

5.7.2 Equipment

The following equipment is required (as applicable) for low flow purging and sampling:

- Adjustable rate, submersible pump (e.g., centrifugal or bladder pump constructed of stainless steel or Teflon).

- Disposable clear plastic bottom filling bailers may be used to check for and obtain samples of LNAPLs or DNAPLs.

- Tubing - Teflon, Teflon-lined polyethylene, polyethylene, PVC, Tygon, or stainless steel tubing can be used to collect samples for analysis, depending on the analyses to be performed and regulatory requirements.
- Water level measuring device, 0.01 foot accuracy, (electronic devices are preferred for tracking water level drawdown during all pumping operations).
- Interface probe, if needed.
- Flow measurement supplies.
- Power source (generator, nitrogen tank, etc.). If a gasoline generator is used, it must be located downwind and at a safe distance from the well so that the exhaust fumes do not contaminate the samples.
- Indicator parameter monitoring instruments - pH, turbidity, specific conductance, and temperature. Use of a flow-through cell is recommended. Optional Indicators - ORP, salinity, and dissolved oxygen, flow-through cell is required. Standards to perform field calibration of instruments.
- Decontamination supplies.
- Logbook(s), and other forms (see Attachments B and C).
- Sample Bottles.
- Sample preservation supplies (as required by the analytical methods).
- Sample tags and/or labels.
- Well construction data, location map, field data from last sampling event (if available).
- Field Sampling Plan.
- PID or FID instrument for measuring VOCs (volatile organic compounds).

5.7.3 Purging and Sampling Procedure

Open monitoring well, measure head space gases using PID/FID. If there is an indication of off gassing when opening the well, wait 3-5 minutes to permit water level an opportunity to reach equilibrium.

Measure and record the water level immediately prior to placing the pump in the well.

Lower pump or tubing slowly into the well so that the pump intake is located at the center of the saturated screen length of the well. If possible keep the pump intake at least two feet above the bottom of the well, to minimize mobilization of sediment that may be present in the bottom of the well. Collection of turbidity-free water samples may be difficult if there is three feet or less of standing water in the well.

Start with the initial pump rate set at approximately 0.1 liters/minute. Use a graduated cylinder and stopwatch to measure the pumping rate. Adjust pumping rates as necessary to prevent drawdown from exceeding 0.3 feet during purging. If no drawdown is noted, the pump rate may be increased (to a max of 0.4 liters/minute) to expedite the purging and sampling event. The pump rate will be reduced if turbidity is greater than 10 NTUs after all other field parameters have stabilized. If groundwater is drawn down below the top of the well screen, purging will cease or the well will be pumped to dryness and the well will be allowed to recover before purging continues. Slow recovering wells will be identified and purged at the beginning of the workday. If possible, samples will be colleted from these wells within the same workday and no later than 24 hours after the start of purging.

Measure the well water level using the water level meter every 5 to 10 minutes. Record the well water level on the Low-Flow Purge Data Form (Attachment C).

Record on the Low-Flow Purge Data Form every 5 to 10 minutes the water quality parameters (pH, specific conductance, temperature, turbidity, oxidation-reduction potential, dissolved oxygen and salinity or as specified by the approved site specific work plan) measured by the water quality meter and turbidity meter. If the cell needs to be cleaned during purging operations, continue pumping (allow the pump to discharge into a container) and disconnect the cell. Rinse the cell with distilled/deionized water. After cleaning is completed, reconnect the flow-through cell and continue purging. Document the cell cleaning on the Low-Flow Purge Data Form.

Measure the flow rate using a graduated cylinder. Remeasure the flow rate any time the pump rate is adjusted.

During purging, check for the presence of bubbles in the flow-through cell. The presence of bubbles is an indication that connections are not tight. If bubbles are observed, check for loose connections.

After stabilization is achieved, sampling can begin when a minimum of two saturated screen volumes have been removed and three consecutive readings, taken at 5 to 10 minute intervals, are within the following limits:

- pH ±0.2 standard units
- Specific conductance ±10%
- Temperature ±10%
- Turbidity less than 10 NTUs
- Dissolved oxygen ±10%

If the above conditions have still not been met after the well has been purged for 4 hours, purging will be considered complete and sampling can begin. Record the final well stabilization parameters from the Low-Flow Purge Data Form onto the Groundwater Sample Log Form.

VOC samples are preferably collected first, directly into pre-preserved sample containers. Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

If the water column in the pump tubing collapses (water does not completely fill the tubing) before exiting the tubing, use one of the following procedures to collect VOC samples: (1) Collect the non-VOCs samples first, then increase the flow rate incrementally until the water column completely fills the tubing, collect the sample and record the new flow rate; (2) reduce the diameter of the existing tubing until the water column fills the tubing either by adding a connector (Teflon or stainless steel), or clamp which should reduce the flow rate by constricting the end of the tubing; (3) insert a narrow diameter Teflon tube into the pump's tubing so that the end of the tubing is in the water column and the other end of the tubing protrudes beyond the pump's tubing, collect sample from the narrow diameter tubing.

Prepare samples for shipping as per SOP SA-6.1.

6.0 REFERENCES

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ATTACHMENT A

PURGING EQUIPMENT SELECTION

Diameter Casing		Bailer	Peristaltic Pump	Vacuum Pump	Air-lift	Diaphragm "Trash" Pump	Submersible Diaphragm Pump	Submersible Electric Pump	Submersible Electric Pump w/Packer
1.25-Inch	Water level <25 feet	X	X	X	X	X			
	Water Level >25 feet	X			X				
2-Inch	Water level <25 feet	X	X	X	X	X	X		
	Water Level >25 feet	X			X		X		
4-Inch	Water level <25 feet	X	X	X	X	X	X	X	X
	Water Level >25 feet	X			X		X	X	X
6-Inch	Water level <25 feet				X	X		X	X
	Water Level >25 feet				X			X	X
8-Inch	Water level <25 feet				X	X		X	X
	Water Level >25 feet				X			X	X

ATTACHMENT A

PURGING EQUIPMENT SELECTION

PAGE 2

Manufacturer	Model Name/Number	Principle of Operation	Maximum Outside Diameter/Length (Inches)	Construction Materials (w/Lines and Tubing)	Lift Range (ft)	Delivery Rates or Volumes	1982 Price (Dollars)	Comments
BarCad Systems, Inc.	BarCad Sampler	Dedicated; gas drive (positive displacement)	1.5/16	PE, brass, nylon, aluminum oxide	0-150 with std. tubing	1 liter for each 10-15 feet of submergence	$220-350	Requires compressed gas; custom sizes and materials available; acts as piezometer.
Cole-Parmer Inst. Co.	Master Flex 7570 Portable Sampling Pump	Portable; peristaltic (suction)	<1.0/NA	(not submersible) Tygon®, silicone Viton®	0-30	670 mL/min with 7015-20 pump head	$500-600	AC/DC; variable speed control available; other models may have different flow rates.
ECO Pump Corp.	SAMPLifier	Portable; venturi	<1.5 or <2.0/NA	PP, PE, PVC, SS, Teflon®, Tefzel®	0-100	0-500 mL/min depending on lift	$400-700	AC, DC, or gasoline-driven motors available; must be primed.
Geltek Corp.	Bailer 219-4	Portable; grab (positive displacement)	1.66/38	Teflon®	No limit	1,075 mL	$120-135	Other sizes available.
GeoEngineering, Inc.	GEO-MONITOR	Dedicated; gas drive (positive displacement)	1.5/16	PE, PP, PVC, Viton®	Probably 0-150	Approximately 1 liter for each 10 feet of submergence	$185	Acts as piezometer; requires compressed gas.
Industrial and Environmental Analysts, Inc. (IEA)	Aquarius	Portable; bladder (positive displacement)	1.75/43	SS, Teflon®, Viton®	0-250	0-2,800 mL/min	$1,500-3,000	Requires compressed gas; other models available; AC, DC, manual operation possible.
IEA	Syringe Sampler	Portable; grab (positive displacement)	1.75/43	SS, Teflon®	No limit	850 mL sample volume	$1,100	Requires vacuum and/or pressure from hand pump.
Instrument Specialties Co. (ISCO)	Model 2600 Well Sampler	Portable; bladder (positive displacement)	1.75/50	PC, silicone, Teflon®, PP, PE, Detrin®, acetal	0-150	0-7,500 mL/min	$990	Requires compressed gas (40 psi minimum).
Keck Geophysical Instruments, Inc.	SP-81 Submersible Sampling Pump	Portable; helical rotor (positive displacement)	1.75/25	SS, Teflon®, PP, EPDM, Viton®	0-160	0-4,500 mL/min	$3,500	DC operated.
Leonard Mold and Die Works, Inc.	GeoFilter. Small Diameter Well Pump (#0500)	Portable; bladder (positive displacement)	1.75/38	SS, Teflon®, PC, Neoprene®	0-400	0-3,500 mL/min	$1,400-1,500	Requires compressed gas (55 psi minimum); pneumatic or AC/DC control module.
Oil Recovery Systems, Inc.	Surface Sampler	Portable; grab (positive displacement)	1.75/12	acrylic, Detrin®	No limit	Approximately 250 mL	$125-160	Other materials and models available; for measuring thickness of "floating" contaminants.
Q.E.D. Environmental Systems, Inc.	Well Wizard® Monitoring System (P-100)	Dedicated; bladder (positive displacement)	1.66/36	PVC	0-230	0-2,000 mL/min	$300-400	Requires compressed gas; piezometric level indicator; other materials available.

ATTACHMENT A

PURGING EQUIPMENT SELECTION

PAGE 3

Manufacturer	Model Name/Number	Principle of Operation	Maximum Outside Diameter/Length (Inches)	Construction Materials (w/Lines and Tubing)	Lift Range (ft)	Delivery Rates or Volumes	1982 Price (Dollars)	Comments
Randolph Austin Co.	Model 500 Vari-Flow Pump	Portable; peristaltic (suction)	<0.5/NA	(Not submersible) Rubber, Tygon®, or Neoprene®	0-30	See comments	$1,200-1,300	Flow rate dependent on motor and tubing selected; AC operated; other models available.
Robert Bennett Co.	Model 180	Portable; piston (positive displacement)	1.8/22	SS, Teflon®, Delrin® PP, Viton®, acrylic, PE	0-500	0-1,800 mL/min	$2,600-2,700	Requires compressed gas; water level indicator and flow meter; custom models available.
Slope Indicator Co. (SINCO)	Model 514124 Pneumatic Water Sampler	Portable; gas drive (positive displacement)	1.9/18	PVC, nylon	0-1,100	250 mL/flushing cycle	$250-350	Requires compressed gas; SS available; piezometer model available; dedicated model available.
Solinst Canada Ltd.	5W Water Sampler	Portable; grab (positive displacement)	1.9/27	PVC, brass, nylon, Neoprene®	0-330	500 mL	$1,300-1,800	Requires compressed gas; custom models available.
TIMCO Mfg. Co., Inc.	Std. Bailer	Portable; grab (positive displacement)	1.66/Custom	PVC, PP	No limit	250 mL/ft of bailer	$20-60	Other sizes, materials, models available; optional bottom-emptying device available; no solvents used.
TIMCO	Air or Gas Lift Sampler	Portable; gas drive (positive displacement)	1.66/30	PVC, Tygon®, Teflon®	0-150	350 mL/flushing cycle	$100-200	Requires compressed gas; other sizes, materials, models available; no solvents used.
Tole Devices Co.	Sampling Pump	Portable; bladder (positive displacement)	1.38/48	SS, silicone, Delrin®, Tygon®	0-125	0-4,000 mL/min	$800-1,000	Compressed gas required; DC control module; custom built.

Construction Material Abbreviations:

PE	Polyethylene
PP	Polypropylene
PVC	Polyvinyl chloride
SS	Stainless steel
PC	Polycarbonate
EPDM	Ethylene-propylene diene (synthetic rubber)

Other Abbreviations:

NA	Not applicable
AC	Alternating current
DC	Direct current

NOTE: Other manufacturers market pumping devices which could be used for groundwater sampling, though not expressly designed for this purpose. The list is not meant to be all-inclusive and listing does not constitute endorsement for use. Information in the table is from sales literature and/or personal communication. No skimmer, scavenger-type, or high-capacity pumps are included.

Source: Barcelona et al., 1983.

ATTACHMENT B
GROUNDWATER SAMPLE LOG SHEET

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: ____________
Project No.: ____________

[ ] Domestic Well Data
[x] Monitoring Well Data
[ ] Other Well Type: ____________
[ ] QA Sample Type: ____________

Sample ID No.: ____________
Sample Location: ____________
Sampled By: ____________
C.O.C. No.: ____________
Type of Sample:
[X] Low Concentration
[ ] High Concentration

SAMPLING DATA:								
Date:	Color	pH	S.C.	Temp.	Turbidity	DO	ORP	Other
Time:	Visual	Standard	mS/cm	Degrees C	NTU	mg/l	mV	NA
Method:								

PURGE DATA:								
Date:	Volume	pH	S.C.	Temp. (C)	Turbidity	DO	ORP	Other
Method:								
Monitor Reading (ppm):			SEE LOW FLOW PURGE DATA SHEET					
Well Casing Diameter & Material Type:								
Total Well Depth (TD):								
Static Water Level (WL):								
One Casing Volume(gal/L):								
Start Purge (hrs):								
End Purge (hrs):								
Total Purge Time (min):								
Total Vol. Purged (gal/L):								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected

OBSERVATIONS / NOTES:

Circle if Applicable:		Signature(s):
MS/MSD	Duplicate ID No.:	

ATTACHMENT C
LOW FLOW PURGE DATA SHEET

LOW FLOW PURGE DATA SHEET

PROJECT SITE NAME: ____________________ WELL ID.: ____________________
PROJECT NUMBER: ____________________ DATE: ____________________

Time (Hrs.)	Water Level (Ft. below TOC)	Flow (mL/Min.)	pH (S.U.)	S. Cond. (mS/cm)	Turb. (NTU)	DO (mg/L)	Temp. (Celcius)	ORP mV	Salinity % or ppt	Comments

SIGNATURE(S): ____________________ PAGE___OF___

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FIGURES

1.0 PURPOSE

This Standard Operating Procedure (SOP) provides an overview of current techniques used to rapidly determine the presence or absence of various target organic compounds at hazardous waste sites. This SOP also describes the functions and capabilities of available instrumentation and provides suggestions of adapted methods suitable to the use and constraints of mobile laboratories. The purpose of this SOP is not to establish standardized analytical procedures, but to describe the concepts employed in field screening analyses. The purpose also is to provide guidance in the application of the best methodology practicable, based upon site-specific requirements, with consideration given to native interferences, specific data quality objectives, and variances in available instrumentation.

2.0 SCOPE

Field screening techniques provide for quantitative analysis of specified compounds by use of portable or transportable instruments based at, or near, a sampling site. As such, field screening provides unique information, and it is therefore important to understand the usability of the data generated. Because of the sophistication of the instruments used and their ability to identify specific compounds, field screening analysis should not be confused with non-specific techniques (for example, the process of obtaining total organic vapor readings from portable meters). However, because field screening results are not typcially confirmed (i.e., are generated by non-confirmatory columns and detectors) and are supported by only moderate control criteria, field screening data may not be suitable for assessing risk.

The main asset of field screening lies in quick turn-around time and specific (though typically not confirmed) data, which are suitable for support in field decisions involving, for example, the best placement of well screens, the optimal positioning of monitoring wells, the focusing of sample submissions to fixed-base laboratories (i.e., the selection of samples that will yield the most important information), the delineation of contaminant plumes, the evaluation of unexpected exposures to the field crew, and fundamental regulatory/remedial support. In this manner, field screening allows for decisions to be made on a real-time basis while the field team is mobilized, thus avoiding the lag time which occurs when waiting for fixed-base laboratory results.

Field screening techniques are applicable to the analysis of air, soil gas, water and solid matrices for various volatile, semi-volatile, pesticide, and PCB compounds. For correlative and quality control purposes, field screening is usually performed in conjunction with a previously established percentage of sample submissions sent to a fixed-base laboratory as split-sample analyses.

3.0 GLOSSARY

<u>Affinity</u> - Molecular attraction

<u>Inert Gas</u> - Non-reactive gas, such as nitrogen or helium, which are commonly used as purge/carrier gas.

<u>Isothermal</u> - At constant temperature.

<u>Neat</u> - Undiluted.

<u>Suspect</u> - Estimated; of questionable accuracy.

<u>Target Compound</u> - Of the host of plausible compounds (i.e., compounds that would be recognized by the methodology used), the specific compounds chosen for analysis that are felt to be representative of site contamination. Typically, a few compounds are selected and monitored, thus facilitating the analytical effort.

4.0 RESPONSIBILITIES

Personnel and assigned duties essential to the accomplishment of the above two tasks are outlined below:

- Project Manager - Responsible for developing, in consultation with other project personnel (e.g., geologists, chemists, engineers, toxicologists, client), a comprehensive work plan in which field screening activities are defined.
- Field Operation Leader - Responsible for the direct supervision of site activities.
- Sampler - Responsible for conducting sampling for submission to the mobile laboratory and fixed-base laboratory, packaging and shipment of samples to the fixed-base laboratory, and the preparation of all necessary paper work associated with sampling and shipment.
- Site Chemist - Responsible for the receipt and analysis of samples submitted to the mobile laboratory for targeted analysis. Responsible for giving guidance in conjunction with the interpretation and appropriate use of the field screening data. Responsible for the oversight of analytical QA/QC.

5.0 PROCEDURES

The following subsections discuss methodologies that have been applied successfully in the field screening of environmental samples obtained from hazardous waste sites. These methodologies are not stand-alone protocols and are not intended to serve as standardized analytical procedures. These methodologies are presented as formats within which analytical approaches, based on the referenced established methods, may be developed to fit site specific needs and data quality objectives. It is necessary for the site chemist and the project manager to address the specific modifications to the procedures that will be employed and to obtain the necessary approval prior to the commencement of site activities.

5.1 Field Screening of Target Purgeable Volatile Organic Compounds (Aqueous Matrix)

5.1.1 Overview

The following methodology describes a modification of EPA 600 series purge and trap gas chromatographic procedures suitable for the determination of volatile organic contaminants in aqueous matrix samples.[1] Via this methodology, a portion of neat sample or dilution is placed into a glass sparging vessel which is sealed onto a purging device. The contained sample aliquot is subjected to a stream of inert gas which is allowed to bubble through the matrix. This mechanical bubbling action effectively strips the contaminants (now volatilized) from the aqueous matrix and sweeps them onto a packed sorbent tube (i.e., trap), where they are subsequently desorbed (by the action of heat and reverse gas flow) onto a suitable column, housed in a pre-programmed gas chromatograph (GC). The contaminants become separated and resolved as they travel through the GC column. Eventually, the contaminants elute through an appropriate detector. The detector signals are processed and interpreted via a previously programmed integrator. Figure 1 provides a list of Potential Volatile Target Compounds.

[1] (EPA Methods 601, 602, 612, and 624).

FIGURE 1

SUMMARY OF POTENTIAL TARGET COMPOUNDS

(Volatile Organics Analysis)
Acetone
Benzene
Bromoform
Carbon Tetrachloride
Chlorobenzene
Chloroform
Ethylbenzene
Methylene chloride
1,1-Dichloroethene
total 1,2-Dichloroethenes
1,1-Dichloroethane
1,2-Dichloroethane
1,1,1-Trichloroethane
Tetrachloroethene
Toluene
Trichloroethene
Total Dichlorobenzenes
Total Xylenes
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)

5.1.2 Summary of Methods

Low Level Analysis - Use of 20 mL neat sample aliquot is suggested in order to achieve reportable detection limits of approximately 5 µg/L. Sample aliquots should be introduced into the sparger using a 10 mL GC syringe. Sample aliquots should not be pipetted, as the action of pipetting may compromise sample integrity due to mechanical stripping.

Medium Level Analysis - Proportioned dilutions may be achieved by using a reduced sample aliquot plus a complementary portion of organic-free water for sparging. For example, a four-fold dilution can be simulated by injecting 5 mL of neat sample plus 15 mL of organic-free water. Similarly, extremely high concentration samples may be analyzed by spiking µL aliquots of neat sample in 19+ mL of organic-free water.

5.1.3 Interferences

Interferences can result from many sources, considering the environmental settings of most hazardous waste sites. However, most interfering impurities are artifacts originating from organic compounds within the specialty gases and the plumbing within the purging mechanism. Interferences in the analytical system are monitored by the analysis of method blanks. Method blanks are analyzed under the same conditions and at the same time as standards and samples, to establish an average background response.

Samples can become contaminated by the diffusion of high concentration contaminants to lower concentrated samples through container seals during shipping and storage. If opted as part of the analysis plan, organic-free trip blanks may be developed and carried by the sampling team together with field samples to assess the existence and the magnitude of this phenomenon.

Artifacts, which manifest themselves as carryover in the next analytical run, can also occur within the analytical apparatus whenever a highly contaminated sample is introduced. To preclude this from occurring, the sample line and sparge vessel are thoroughly rinsed with organic-free water prior to the bake cycle of each highly contaminated sample run.

5.1.4 Major Apparatus and Materials

Purge and Trap Device - Tekmar Company Model LSC-2 or equivalent complete with a 25 mL glass sparge vessel and a 1/8-inch-O.D. x 25-cm-long stainless steel trap. The trap may be packed solely with Tenax. Alternately, trap packing may consist of 1.0 cm of 3 percent OV-1, 15 cm of Tenax and 8 cm of silica gel. Appropriate trap selection is contingent upon the target compounds being analyzed.

Gas Chromatograph (GC) - Hewlett Packard 5890 or equivalent. The analytical system should be equipped for temperature programming, packed and/or capillary column analysis, and direct-column injection.

Detector - PID/FID or PID/HECD in series; FID only. Optimum detector selection should be based upon the sensitivities of the target compounds being analyzed.

Analytical Column - Glass or stainless steel column packed with 1 percent SP-1000 on 60/80 mesh Carbopack B. Alternatively a suitable capillary column may be used.

Syringes - Assorted: 5 µL, 25 µL, 100 µL, 1 mL, 10 mL.

Volumetric Flasks - 10 mL, 25 mL, 100 mL.

Analytical Balance - Capable of accurately weighing 0.0001 g.

Oven - Constant temperature for the regeneration of contaminated apparatus.

Refrigerators - One dedicated refrigerator each for separate sample and standard storage. Each should be capable of maintaining a stable temperature of 4bC.

5.1.5 Reagents

Methanol - Pesticide grade or equivalent.

Organic-Free Water - Supplied by laboratory or purchased.

Neat Solvents - 96 percent purity, or better, for each compound of interest.

5.1.6 Calibration

Standards - Calibration standards containing the compounds of interest are prepared in methanol by either diluting commercially purchased stock standard mixes or by creating in-house standards from pure solvents. In-house calibration standards are prepared gravimetrically, in that an appropriate µL aliquot of each target compound is introduced into a known volume of methanol. The appropriate µL aliquot of compound is based upon the compound's density and response to the selected detector. Calibration standards are created at a level such that a 2-5 µL spike of standard into 20 mL of organic-free water is suitable for continuing calibration purposes.

Peak Identification. Compound identities may be substantiated by the analysis of each individual component, thereby documenting compound retention time.

Initial Linearity. An initial three-point calibration curve is generated by the analysis of multiple-aliquot injections of calibration standard. For example, if the calibration standard is created such that a 2 µL spike into organic-free water yields results at the level of the reported detection limits, a three-point calibration curve may be achieved by the analysis of 2 µL, 5 µL, and 10 µL aliquot spikes. The linearity study for field screening is conducted in such a way as to substantiate the performance of the detector at the level of the reportable limits. It is not performed to demonstrate the entire range of detector capability.

Integration. Calibration of the analytical system is achieved via the external standard method in which response factors (RF) for each compound are obtained by the analysis of a standard mix of known concentration. Following the analysis of this known standard mix, an electronic file is created establishing each peak's identity, retention time, RF, and known concentration. The RF for each target compound is determined by dividing the known concentration by the associated peak response (area or height units). For initial calibration, each compound's average response factor is determined by averaging the peak response results generated for the initial linearity study. These average response factors are programmed into the integrator to allow for direct concentration reading of contaminants found in subsequent sample analyses.

Continuing Calibration. Calibration of the analytical system should be updated three times daily, using the mid-concentration standard: (1) preceding the daily analysis, (2) mid-day and (3) after the daily analyses.

5.1.7 Gas Chromatography

Preconcentration of sample contaminants is achieved through the purge-and-trap process in which stripped volatile contaminants are adsorbed onto a sorbent trap. The affinity the volatilized organic contaminants have for the special packing inside the sorbent tube cause them to be retained within the tube (i.e., adsorbed onto the packing), while other inert components pass through the tube. The purge and trap process consists of a prepurge cycle (optional), a purge cycle (during which contaminants are stripped away from the sample matrix and are trapped within the sorbent tube), a dry purge cycle (optional), a desorb cycle (in which the contaminants are backflushed off the sorbent tube and onto the GC column), and a bake cycle in which the sorbent tube (trap) is heated (with flow) to a high temperature, regenerating the trap. The selection of the appropriate temperature, options, and duration of the purge and trap processes are contingent upon the target compounds being analyzed. Generally, the following range of conditions apply:

Cycle	Temperature	Duration
Purge	Ambient	8 - 10 minutes
Desorb	180bC	2 - 4 minutes
Bake	215bC	7 - 10 minutes

Desorption of the adsorbed contents of the sorbent trap onto the head of a previously conditioned GC analytical column allows for subsequent analysis by temperature-programmed gas chromatography. The desorbed contaminants are first held at constant temperature (usually in the range of 45-55bC) at the head of the analytical column for a period of 3 to 5 minutes. After this initial time period, the GC oven temperature is raised at a constant rate (usually 8-15bC/minute) until a final temperature of 200-225bC is reached. The final temperature is customarily held for a period of 3 to 10 minutes.

The affinity of the volatile contaminants to either the analytical column's mobile or stationary phase, the effect of elevated temperature, and the action of the carrier gas flow through the column cause the volatile contaminants to become separated and resolved, allowing them to elute in bands through the selected detector. As long as the analytical conditions remain constant, each type of volatile component will elute at a characteristic retention time (RT). In this manner, sample contaminants are identified and quantified by comparison to a run of a standard mix containing known compounds and concentrations.

Quantitation of volatile contaminants in aqueous matrix samples is calculated based upon the following formula:

$$\text{Concentration sample } (\mu g/L) = \text{target peak response (sample)} \times RF \times DF$$

$$\text{where: } RF \text{ (Response Factor)} = \frac{\text{Target Concentration Std. } (\mu g/L)}{\text{Target Peak Response Std.}}$$

DF (Dilution Factor) is used when applicable

5.2 Field Screening of Target Purgeable Volatile Organic Compounds (Solid Matrix)

5.2.1 Overview

The following methodology describes a modification of SW846 analytical procedures suitable for the determination of volatile organic contaminants in solid matrix samples.[2] Via this methodology a portion of sample matrix, or extract, is placed into a glass sparging vessel along with 5-10 mL of organic-free water. The sparge vessel is then sealed onto a purging device. The contained sample (or extract) aliquot is heated while a stream of inert gas is bubbled through the slurry. The mechanical bubbling action effectively strips the contaminants (now volatilized) from the matrix slurry and sweeps them onto a packed sorbent tube (i.e., trap) where they are subsequently desorbed (by action of heat and reverse gas flow)

[2] (SW846 Methods 5030B/5035, 8015B, 8021B, 8121, 8260B, and 3580A).

onto a suitable column, housed by a pre-programmed gas chromatograph (GC). The volatile contaminants become separated and resolved as they travel through the GC column. Eventually the contaminants elute through an appropriate detector. The detector signals are processed and interpreted by a previously programmed integrator (see Figure 1 for a list of Potential Volatile Target Compounds).

5.2.2 Summary of Methods

Low Level Analysis. Use of a 5 gram sample is suggested to achieve reportable detection limits of approximately 5 µg/kg. The solid matrix (free of obvious pebbles and unrepresentative organic matter) should be quickly measured directly into a tared sparge vessel. After the exact weight of sample is recorded, 5 mL of organic-free water is introduced into the sparger. A heated purge is required.

Medium Level Analysis. Simple dilutions may be achieved by using a reduced portion of the solid matrix (i.e., 1-<5 grams) and a complementary portion of 9 to 5 mL organic-free water. For example, a 2.5X dilution can be simulated by adding 8 mL of organic-free water to 2 grams of weighed matrix. Moderate to high concentration samples are prepared by extracting a 5 gram portion of solid matrix with 10 mL methanol. A suitable aliquot of the methanol extract (usually 10 µL to 200 µL) is then spiked into a sparge vessel containing 10 mL organic-free water. Note that the 1:2 ratio of sample to solvent has introduced a two-fold dilution. The additional dilution factor based upon the µL injection used must also be taken into consideration.

5.2.3 Interferences

The analysis of volatile organic contaminants in solid matrix samples is susceptible to the same interferences discussed in Subsection 5.1.3. Additionally, some chromatographic artifacts may occur due to impurities present in the methanol used to extract medium/high concentration samples.

5.2.4 Major Apparatus and Materials

In addition to the equipment listed in Subsection 5.1.4, the following devices and materials are required:

Sparge Heater - Tekmar Model 4100 or equivalent. Must be capable of maintaining constant temperature during the purge process.

Pipettes - Assorted glass disposable: 1 mL, 5 mL, 10 mL.

Vials - 15 mL septum-seal for storage of sample extracts.

Vials - 40 mL septum-seal for use in extracting contaminants from sample matrix.

Glass Marking Pen - For labeling vials.

Laboratory Timer - To use during the extraction process.

Aluminum Weighing Pans - For use in determining moisture content of the sample matrix.

5.2.5 Reagents

Reagents are as outlined in Subsection 5.1.5.

5.2.6 Calibration

Standard preparation, peak identification, initial linearity, integration, and continuing calibration are accomplished as outlined in Subsection 5.1.6.

5.2.7 Sample Preparation

Medium to high concentration samples are extracted in methanol prior to chromatographic analysis. The following extraction protocol is suggested:

- Weigh and tare a 40 mL septum-seal vial using an analytical balance.
- Add 5.0 grams of sample matrix to the vial; record weight.
- Pipet a 10 mL volume of methanol into the vial. Assuming 100 percent transference of contaminants from matrix to methanol, note that a 2X dilution factor has been introduced.
- Remove the vial from the analytical balance, cap and shake vigorously for 2 full minutes (alternatively, vial contents may be sonicated).
- Set the vial aside and allow the contents to settle for 5 minutes.
- Pipet off the supernatant extract into a labeled 15 mL vial.
- Perform a gas chromatographic analysis by spiking 10 µL-200 µL of the methanol extract into approximately 10 mL organic-free water. Calculate total dilution (deviation) from the original 5 gram sample base.

5.2.8 Gas Chromatography

The same chromatographic theory and GC run conditions outlined in Subsection 5.1.7 are applicable to the volatile organic analysis of solid matrix samples with the following additions:

Prepurge and dry-purge options of the purge and trap process are recommended; a heated purge is required. Sample prepurge enhances subsequent chromatography by allowing air molecules present in the sparge vessel to be replaced by inert purge gas molecules prior to the actual purge cycle. The dry-purge option follows the purge cycle. Dry-purge removes water vapor from the trap tube prior to the desorb cycle. The selection of appropriate purge and trap conditions are contingent upon the target compounds being analyzed. Generally, the following range of conditions apply:

Cycle	Temperature	Duration
Prepurge/Preheat	Ambient/to 40bC	2 minutes/1 minute
Purge	40bC	8 - 10 minutes
Dry-Purge	40bC	2 minutes
Desorb	180bC	3 - 5 minutes
Bake	215bC	7 - 10 minutes

Due to the extraction process and the need to correct the final value for moisture content, the quantitation of volatile contaminants in solid matrix samples is calculated based upon the following formula:

$$\text{Concentration (ug/kg)} = \text{Sample Peak Response (Area or Height)} \times \text{RF} \times 1/\text{wt. of sample extract(g)} \times \text{final volume (mL)} \times 1/\%\ \text{solids}$$

$$\text{where : RF (Response Factor)} = \frac{\text{Target Conc. Std. } (\mu\text{g/L})}{\text{Target Peak Response Std.}}$$

$$\%\ \text{solids} = 100 - \%\ \text{moisture}$$

$$\%\ \text{moisture} = \frac{\text{Wet wt.} - \text{Dry wt.}}{\text{Wet wt.}} \times 100$$

The protocol for determining percent moisture is presented in Subsection 5.12.

5.3 Field Screening of Target Semivolatile Organic Compounds (Aqueous Matrix)

5.3.1 Overview

The following methodology describes a modification of SW846 preparative and EPA 600 series analytical gas chromatographic procedures suitable for the determination of semi-volatile contaminants in aqueous matrix samples.[3] Via this methodology, a portion of neat sample is extracted using rapid field techniques. An aliquot of sample extract is then directly injected onto an analytical column housed by a previously calibrated gas chromatograph (GC). The semi-volatile compounds are resolved by temperature-programmed gas chromatography and are detected by an FID (Flame Ionization Detector). The detector signals are processed and interpreted via a previously programmed integrator. Figure 2 provides a list of Potential Target Compounds.

5.3.2 Summary of Method

Low Level Analysis - Use of 25 mL neat sample aliquot is suggested. Detection limits vary per each compound sensitivity to the detector. Detection limits of approximately 100 µg/L to 800 µg/L are achievable.

Medium Level Analysis - Proportioned dilutions may be achieved by using a reduced sample aliquot. For example, a five-fold dilution can be simulated by extracting only 5 mL neat sample while retaining the same volume of extraction solvent.

5.3.3 Interferences

Interferences inherent to this procedure stem from four major sources: (1) impurities present in the solvents used for extraction, (2) system artifacts caused by insufficient column conditioning (3) residual contamination remaining on improperly cleaned glassware and (4) matrix interferences caused by co-extracted organic matter.

Interferences in the analytical system are monitored by the analysis of method blanks. Method blanks are analyzed under the same conditions and at the same time as standards and samples, in order to establish average background response.

[3] (SW846 Methods 3550B and 3580A; EPA Methods 604, 605, 610, 611, and 625).

FIGURE 2

SUMMARY OF POTENTIAL TARGET COMPOUNDS

(Semivolatile Organics Analysis)	
Acenaphthene	Hexachloroethane
Acenaphthylene	Naphthalene
Anthracene	2-Chloronaphthalene
Benzo(a)anthracene	2-Methylnaphthalene
Benzo(a)pyrene	Phenanthrene
total Benzofluoranthenes	Pyrene
Butyl benzyl phthalate	1,2,4-Trichlorobenzene
Chrysene	total Dichlorobenzenes
Diethyl phthalate	Phenol
Dimethyl phthalate	2-Chlorophenol
Di-n-butyl phthalate	2,4-Dichlorophenol
Di-n-octyl phthalate	2,4,5-Trichlorophenol
Fluoranthene	2,4,6-Trichlorophenol
Fluorene	2-Methylphenol
Hexachlorobenzene	4-Methylphenol
Hexachlorobutadiene	2,4-Dimethylphenol
Hexachlorocyclopentadiene	4-Chloro-3-methylphenol

Artifacts, which manifest themselves as carryover in the next analytical run, can also occur within the analytical apparatus whenever a highly contaminated sample is introduced. To preclude this from occurring, injection syringes are repeatedly flushed with solvent and the analytical column is baked for a short period of time following each direct injection analysis.

5.3.4 Major Apparatus and Materials

Gas Chromatograph - Hewlett Packard 5890 or equivalent. The analytical system should be equipped for packed or capillary column analysis with a temperature programmable oven and on-column injection capabilities.

Detector - Flame Ionization Detector (FID).

Analytical Column - Better resolution is achieved through use of a capillary column (such a DB-5 or equivalent). However, a packed column, such as 3 percent SP-2250 on 100/120 mesh Supelcoport, is more practical for field use.

Syringes - Assorted: 5 µL, 25 µL, 100 µL, 1 mL.

Analytical Balance - Capable of accurately weighing 0.0001 g.

Vials - 40 mL septum-seal for extraction.

Vials - 2 dram septum-seal for extract storage.

Pipets - Assorted: 1 mL, 5 mL, 10 mL; disposable glass.

Refrigerator - Separate for sample and standard storage. Capable of maintaining a stable temperature of 4bC.

Glass Marking Pen - For labeling vials.

Laboratory Timer - To use during the extraction process.

Hydrion Paper - To measure pH.

5.3.5 Reagents

Methanol - Pesticide grade or equivalent.

Methylene Chloride - Pesticide grade or equivalent.

Sulfuric Acid - 1N, reagent grade.

Neat Standards - 96 percent purity or better for each compound of interest.

5.3.6 Calibration

Standards. Calibration standards containing the compounds of interest are prepared from commercially purchased standard mixes or pure compound. All standards are made and/or diluted using a 1:1 mixture of methylene chloride: methanol and are created for use via a 2 µL direct injection.

Peak Identification. Compound identities may be substantiated by the analysis of each individual component thereby documenting compound retention time.

Initial Linearity. An initial three point calibration curve is generated by the analysis of multiple-aliquot injections of calibration standard. For example, if the calibration standard is created such that a 2 µL spike yields results at the level of the reported detection limits, a three-point calibration curve may be achieved by the analysis of 2 µL, 5 µL and 10 µL aliquot spikes.

Calibration. Calibration of the analytical system is achieved via the external standard method, in which response factors (RF) for each compound are obtained by the analysis of a standard mix of known concentration. Following the analysis of this known standard mix, an electronic file is created establishing each peak's identity, retention time, RF and known concentration. The RF for each peak is determined by dividing the known concentration by the peak response (area or height units) of the associated peak. For initial calibration, each compound's average response factor is determined by averaging the peak response results generated for the initial linearity study. These average response factors are programmed into the integrator to allow for direct concentration reading of contaminants found in subsequent sample analyses.

Continuing Calibration. Calibration of the analytical system should be updated three times daily: (1) preceding the daily analyses, (2) mid-day and (3) after the daily analyses. Continuing calibration should be conducted at a concentration level equal to the reported detection limits.

5.3.7 Sample Preparation

All samples must be extracted prior to chromatographic analysis. The suggested protocol follows:

- Pipet 25 mL of aqueous sample matrix each into two 40 mL septum-seal vials; discard pipet.
- Add exactly 2.5 mL of methylene chloride to one of the vial's contents.
- Adjust the pH of the other vial's contents to pH<2 using sulfuric acid.
- Add exactly 2.5 mL methylene chloride to the adjusted contents of the second vial.
- Cap the vials and shake vigorously for 2 minutes.
- Set the vials aside and allow the contents to settle for 5 minutes.
- Combine the extracts by pipetting 1.5 mL each of the supernatant extracts into a 2 dram septum-seal vial.
- Gas chromatographic analysis is performed by directly injecting 2-5 µL of combined sample extract onto the GC's analytical column.

5.3.8 Gas Chromatography

Sample contaminants are first stripped from the matrix by means of methylene chloride extraction (see Subsection 5.3.7). A 2-5 µL aliquot of the sample extract is introduced onto the head of a previously conditioned analytical column by means of direct injection technique. The semi-volatile contaminants are then resolved by temperature-programmed gas chromatography in which the action of carrier gas flow, elevated temperatures and the affinity each semi-volatile compound has for the phases of the column packing cause the contaminants to separate into bands. As the bands of contaminants elute from the column, they are recognized by an FID (Flame Ionization Detector). Detector signals are then processed by a previously programmed integrator. As long as analytical conditions remain constant, each semivolatile compound will elute at a characteristic retention time (RT). In this manner, sample contaminants are identified and quantified by comparison to a run of a standard with known concentrations.

Under the following run conditions, most compounds of interest will elute within 32 minutes:

Run Parameter	Setting
Initial Column Temperature	100bC
Initial Hold Time	1 minute
Rate	10bC/minute
Final Column Temperature	300bC
Carrier Gas Flow	20 mL/minute

These conditions will need to be adjusted as necessary in order to optimize the resolution of the specific compounds of interest.

Appropriate quantitation of sample contaminants is based upon the following formula:

$$\text{Concentration } (\mu g/L) = \text{Target peak response (sample) x RF x DF}$$

$$\text{where : RF (Response Factor)} = \frac{\text{Target Concentration Std. } (\mu g/L)}{\text{Target Peak Response}}$$

$$\text{DF (Dilution Factor) is used when applicable}$$

5.4 Field Screening of Target Semivolatile Organic Compounds (Solid Matrix)

5.4.1 Overview

The following methodology describes a modification of SW846 analytical gas chromatographic procedures suitable for the determination of semi-volatile organic contaminants in solid matrix samples.[4] Via this methodology, a 2 gram portion of a solid sample is extracted using rapid field techniques. An aliquot of the sample extract is then directly injected onto an analytical column for analyses by temperature-programmed gas chromatography. The semi-volatile contaminants are subsequently analyzed by a flame ionization detector (FID). The detector signals are processed by a previously programmed integrator (see Figure 2 for a list of Potential Target Compounds).

5.4.2 Summary of Methods

Low Level Analysis - The extraction of a 2 gram sample portion is suggested to achieve analytical results comparable to approximately 50 mg/kg reportable detection limits.

Medium Level Analysis - Sample dilutions are achieved by diluting a portion of the sample extract (as above) in an appropriate volume of methylene chloride.

[4] (SW846 Methods 3550B and 3580A; 8041; 8061A; 8100; 8270C; and 8310).

5.4.3 Interferences

The analysis of semi-volatile contaminants in solid matrix samples is susceptible to the same interferences discussed in Subsection 5.3.3.

5.4.4 Major Apparatus and Materials

In addition to the equipment listed in Subsection 5.3.4, the following device is required:

Oven - Constant temperature; for use in the determination of moisture content.

5.4.5 Reagents

Methanol - Pesticide grade or equivalent.

Methylene Chloride - Pesticide grade or equivalent.

Sulfuric Acid - 1N, reagent grade.

Neat Standards - 96 percent purity or better for each compound of interest.

Anhydrous Sodium Sulfate - Used to remove moisture from the sample matrix.

5.4.6 Calibration

Standard preparation, peak identification, initial linearity, integration and continuing calibration are accomplished as outlined in Subsection 5.3.6.

5.4.7 Sample Preparation

All samples must be extracted prior to chromatographic analysis. A suggested protocol follows:

- Weigh and tare two 40 mL septum-seal vials using an analytical balance.
- Add 2.0 grams of sample matrix (each) to the two vials. Record both sample weights.
- Add approximately 2 grams of anhydrous sodium sulfate to each vial. Mix the vial contents thoroughly using a clean spatula.
- Add exactly 10 mL of methylene chloride to each vial.
- Invert one vial several times to mix. Adjust the pH of this vial's contents to pH<2 using sulfuric acid.
- Cap the vial and shake vigorously for 2 full minutes (alternately, vial contents may be sonicated).
- Set the vials aside and allow the contents to settle for 5 minutes.
- Combine the extracts by pipetting off exactly 1.5 mL each of the supernatant extracts into a labeled 2-dram septum-seal vial.
- Gas chromatographic analysis is performed by directly injecting a 2-5 µL aliquot of the combined sample extract onto the GC's analytical column.

5.4.8 Gas Chromatography

The same chromatographic theory and GC run conditions outlined in Subsection 5.3.8 are applicable to the semivolatile analysis of solid matrix samples, with one addition:

Due to the extraction process and the need to correct the final value for moisture content, the quantitation of semi-volatile contaminants in solid matrix samples is calculated based upon the following formula:

$$\text{Concentration } (\mu g/kg) = \text{Sample Peak Response (Area or Height)} \times \text{RF} \times 1/\text{wt. of sample extract(g)} \times \text{final volume (mL)} \times 1/\%\text{ solids}$$

$$\text{where: RF (Response Factor)} = \frac{\text{Target Conc. Std. } (\mu g/L)}{\text{Target Peak Response Std.}}$$

$$\%\text{ solids} = 100 - \%\text{ moisture}$$

$$\%\text{ moisture} = \frac{\text{Wet wt.} - \text{Dry wt.}}{\text{Wet wt.}} \times 100$$

The protocol for determining percent moisture is presented in Subsection 5.12.

5.5 Field Screening of Organochlorine Pesticides (Aqueous Matrix)

5.5.1 Overview

The following methodology describes a modification of EPA Method 608. This methodology is suitable for the determination of organochlorine pesticide contaminants in aqueous matrix samples. Via this methodology, a portion of neat sample is extracted using rapid field techniques. An aliquot of sample extract is then directly injected onto an analytical column housed in a previously calibrated gas chromatograph (GC). The pesticide contaminants are resolved isothermally and are detected by an electron capture detector (ECD). Detector signals are processed and interpreted via a previously programmed integrator. Figure 3 provides a list of Potential Target Compounds.

5.5.2 Summary of Methods

Low Level Analysis. A 20 mL neat sample aliquot is suggested to achieve method detection limits of approximately 0.5 µg/L.

Medium Level Analysis. Proportioned dilutions may be achieved by using a reduced sample aliquot. For example, a five-fold dilution can be simulated by extracting only 4 mL neat sample while retaining the same volume of extraction solvent.

5.5.3 Interferences

Interferences inherent to this procedure stem from four major sources: (1) impurities present in the solvents used for extraction, (2) system artifacts caused by insufficient column conditioning, (3) residual contamination remaining on improperly cleaned glassware, and (4) matrix interferences caused by co-extracted organic matter.

FIGURE 3

SUMMARY OF POTENTIAL TARGET COMPOUNDS

(Organochlorine Pesticide Analysis)
Alpha-BHC
Beta-BHC
Delta-BHC
Gamma-BHC (Lindane)
Aldrin
Chlordane
Dieldrin
Endosulfan I
Endosulfan II
Endosulfan sulfate
Endrin
Heptachlor
Heptachlor epoxide
4,4-DDD
4,4-DDE
4,4-DDT

Interferences in the analytical system are monitored by the analysis of method blanks. Method blanks are analyzed under the same conditions and at the same time as standards and samples, in order to establish average background response.

Artifacts, which manifest themselves as carryover in the next analytical run, can also occur within the analytical apparatus whenever a highly contaminated sample is introduced. To preclude this, injection syringes are repeatedly flushed with solvent and the analytical column is baked for a short period of time following each direct injection analysis.

5.5.4 Major Apparatus and Materials

Gas Chromatograph - Hewlett Packard 5890 or equivalent. The analytical system should be equipped for packed or capillary column analysis with isothermal oven and on-column injection capabilities.

Detector - Electron Capture Detector (ECD)

Analytical Column - Glass or stainless steel packed with 1.5 percent SP-2250/1.95 percent SP-2401 on 100/120 mesh Supelcoport. Alternately, a 3 percent OV-1 on 80/100 mesh Supelcoport packed column or a suitable capillary column may be used.

Syringes - Assorted: 5 µL, 25 µL, 100 µL, 1 mL.

Analytical Balance - Capable of accurately weighing 0.0001 g.

Vials - 40 mL septum-seal for extraction.

Vials - 2 dram septum-seal for extract storage.

Glass Marking Pen - For labeling vials.

Laboratory Timer - To use during the extraction process.

Pipets - Assorted: 1 mL, 5 mL, 10 mL; disposable glass.

Refrigerator - Separate for sample and standard storage. Capable of maintaining a stable temperature of 4bC.

5.5.5 Reagents

Hexane - Pesticide grade or equivalent.

Iso-octane - Distilled in glass.

Neat Standards - 96 percent purity or better for each compound of interest.

Zero-Grade Nitrogen - As carrier gas for the gas chromatograph (GC).

5.5.6 Calibration

Standards. Calibration standards containing the compounds of interest are prepared from commercially purchased standard mixes or pure compound. All standards are made and/or diluted using iso-octane and are created for use via a 2 µL injection. An example of a working calibration standard within a practical concentration range follows:

Compound	Concentration
Lindane	0.0125 ng/µL
Aldrin	0.0250 ng/µL
4,4'-DDT	0.0625 ng/µL

Peak Identification. Compound identities may be substantiated by the analysis of each individual component thereby documenting compound retention time.

Initial Linearity. An initial three-point calibration curve is generated by the analysis of multiple-aliquot injections of calibration standard. For example, if the calibration standard is created such that a 2 µL spike yields results at the level of the reported detection limits, a three-point calibration curve may be achieved by the analysis of 2 µL, 5 µL, and 10 µL aliquot spikes.

Calibration. Calibration of the analytical system is achieved via the external standard method in which response factors (RF) for each compound are obtained by the analysis of a standard mix of known concentration. Following the analysis of this known standard mix, an electronic file is created establishing each peak's identity, retention time, RF, and known concentration. The RF for each peak is determined by dividing the known concentration by the peak response (area or height units) of the associated peak. For initial calibration, each compound's average response factor is determined by averaging the peak response results generated for the initial linearity study. These average response factors are programmed into the integrator to allow for direct concentration reading of contaminants found in subsequent sample analyses.

Continuing Calibration. Calibration of the analytical system should be updated three times daily: (1) preceding the daily analysis, (2) mid-day, and (3) after the daily analysis. Continuing calibration should be conducted at a concentration level equal to the reported detection limits.

5.5.7 Sample Preparation

All samples must be extracted prior to chromatographic analysis. Samples are extracted in hexane according to the following suggested protocol:

- Pipet 20 mL aqueous sample matrix into a 40 mL septum-seal vial; discard pipet.
- Add 2.0 mL hexane to the measured matrix aliquot.
- Cap the vial and shake vigorously for 2 minutes.
- Set the vial aside and allow the contents to settle for 5 minutes.
- Pipet off the supernatant extract into a labeled 2 dram septum-seal vial.
- Gas chromatographic analysis is performed by directly injecting 2-5 µL of sample extract onto the GC's analytical column.

5.5.8 Gas Chromatography

Sample contaminants are first stripped from the matrix by means of hexane extraction (see Subsection 5.5.7). A 2-5 µL aliquot of the sample extract is introduced onto the head of a previously conditioned analytical column by means of direct injection technique. The organochlorine pesticide compounds are resolved isothermally due to the affinity each compound has for the phases of the column packing as they migrate (under flow) through the analytical column. As the contaminants elute from the column, they are recognized by an electron capture detector (ECD). Detector signals are then processed by a previously programmed integrator. As long as analytical conditions remain constant, each type of organochlorine compound will elute at a characteristic retention time (RT). In this manner, sample contaminants are identified and quantified by comparison to a run of standard mix of known concentration.

Under the following run conditions all commonly targeted organochlorine pesticides will elute within 15 minutes:

Injection Port Temperature	300bC
Isothermal Oven Temperature	215bC
Detector Temperature	350bC
Carrier Gas Flow	70 mL/minute

Appropriate quantitation of sample contaminants is based upon the following formula:

$$\text{Concentration } (\mu g/L) = \text{Target Peak Response (Sample) x RF x DF}$$

$$\text{where : RF (Response Factor)} = \frac{\text{Target Concentration Std. } (\mu g/L)}{\text{Target Peak Response Std.}}$$

DF (Dilution Factor) is used when applicable

5.6 Field Screening of Organochlorine Pesticides (Solid Matrix)

5.6.1 Overview

The following methodology describes a modification of SW846 analytical gas chromatographic procedures suitable for the determination of organochlorine pesticide contaminants in solid matrix samples.[5] Via this methodology, a 5 gram portion of solid sample is extracted using rapid field techniques. A 2-5 µL aliquot of sample extract is then directly injected onto an analytical column for the isothermal resolution of target compounds. The organochlorine pesticide contaminants are detected by an electron capture detector (ECD). Detector signals are processed and interpreted via a previously programmed integrator.

5.6.2 Summary of Method

Low Level Analysis - Use of a 5 gram portion of sample is suggested to achieve method detection limits of approximately 25 µg/kg.

Medium Level Analysis - Sample dilutions are achieved by diluting a portion of the sample extract (as above) in an appropriate volume of iso-octane.

5.6.3 Interferences

The analysis of organochlorine pesticide contaminants in solid matrix samples is susceptible to the same interferences discussed in Subsection 5.5.3.

5.6.4 Major Apparatus and Materials

In addition to the equipment listed in Subsection 5.5.4, the following device is required:

Oven - Constant temperature; for use in the determination of moisture content.

[5] (SW846 Methods 3550B, 3580A, and 8081A).

5.6.5 Reagents

Hexane - Pesticide grade or equivalent.

Iso-Octane - Distilled in glass.

Neat Standards - 96 percent purity or better for each compound of interest.

Zero-Grade Nitrogen - As carrier gas for the gas chromatograph (GC).

Anhydrous Sodium Sulfate - Used to remove moisture from the portion of soil prior to extraction.

5.6.6 Calibration

Standard preparation, peak identification, initial linearity, integration, and continuing calibration are accomplished as outlined in Subsection 5.5.6.

5.6.7 Sample Preparation

All samples must be extracted prior to chromatographic analysis. A suggested extraction protocol follows:

- Weigh and tare a 40 mL septum-seal vial using an analytical balance.
- Add 5.0 grams of sample matrix to the vial; record weight.
- Add approximately 3 grams of anhydrous sodium sulfate; mix thoroughly using a clean spatula.
- Pipet 8.0 mL of hexane into the vial.
- Cap the vial and shake vigorously for 2 minutes (alternately, vial contents may be sonicated).
- Set the vial aside and allow the contents to settle for 5 minutes.
- Pipet off the supernatant extract into a labeled 2 dram septum-seal vial.
- Gas chromatographic analysis is performed by directly injecting 2-5 µL of sample extract onto the GC's analytical column.

5.6.8 Gas Chromatography

The same chromatographic theory and GC run conditions outlined in Subsection 5.5.8 are applicable to the pesticide analysis of solid matrix samples, with one modification:

Due to the need to correct the final value for moisture content, the quantitation of pesticide contaminants in solid matrix samples is calculated based upon the following formula:

$$\text{Concentration } (\mu g/kg) = \text{Sample Peak Response (Area or Height)} \times RF \times 1/\text{wt. of sample extract(g)} \times \text{final volume (mL)} \times 1/\%\text{ solids}$$

$$\text{where: } RF\text{ (Response Factor)} = \frac{\text{Target Conc. Std. } (\mu g/L)}{\text{Target Peak Response Std.}}$$

$$\%\text{ solids} = 100 - \%\text{ moisture}$$

$$\%\text{ moisture} = \frac{\text{Wet wt.} - \text{Dry wt.}}{\text{Wet wt.}} \times 100$$

The protocol for determining percent moisture is presented in Subsection 5.12.

5.7 Field Screening of Polychlorinated Biphenyl (PCB) Compounds (Aqueous Matrix)

5.7.1 Overview

The following methodology describes a modification of EPA Methods 608 and 625. This methodology is suitable for the determination of polychlorinated biphenyl (PCB) contaminants in aqueous matrix samples. Via this methodology, a portion of neat sample is extracted using rapid field techniques. An aliquot of sample extract is then directly injected onto an analytical column housed by a previously calibrated gas chromatograph (GC). The PCB contaminants are resolved isothermally and are detected by an electron capture detector (ECD). Detector signals are processed and interpreted via a previously programmed integrator (see Figure 4 for a list of Potential Target Compounds).

5.7.2 Summary of Method

Low Level Analysis - A 20 mL neat sample aliquot is suggested to achieve method detection limits of approximately 15 µg/L.

Medium Level Analysis - Proportioned dilutions may be achieved by using a reduced sample aliquot. For example, a five-fold dilution can be simulated by extracting only 4 mL neat sample while retaining the same volume of extraction solvent.

5.7.3 Interferences

Interferences inherent to this procedure stem from four major sources: (1) impurities present in the solvents used for extraction, (2) system artifacts caused by insufficient column conditioning (3) residual contamination remaining on improperly cleaned glassware and (4) matrix interferences caused by co-extracted organic matter.

Interferences in the analytical system are monitored by the analyses of method blanks. Method blanks are analyzed under the same conditions and at the same time as standards and samples, in order to establish average background response.

Artifacts (which manifest themselves as carryover in the next analytical run) can also occur within the analytical apparatus whenever a highly contaminated sample is introduced. To preclude this, injection syringes are repeatedly flushed with solvent and the analytical column is baked for a short period of time following each direct injection analysis.

5.7.4 Major Apparatus and Materials

Gas Chromatograph - Hewlett Packard 5890 or equivalent. The analytical system should be equipped for packed or capillary column analysis with isothermal oven and on-column injection capabilities.

Detector - Electron Capture Detector (ECD).

Analytical Column - Glass or stainless steel packed with 1.5 percent SP-2250/1.95 percent SP-2401 on 100/120 mesh Supelcoport or equivalent. Alternately, a suitable capillary column may be used.

Syringes - Assorted: 5 µL, 25 µL, 100 µL, 1 ml.

Analytical Balance - Capable of accurately weighing 0.0001 g.

FIGURE 4

SUMMARY OF POTENTIAL TARGET COMPOUNDS

(PCB Analysis)
Aroclor-1016
Aroclor-1221
Aroclor-1242
Aroclor-1248
Aroclor-1254
Aroclor-1260

Vials - 40 mL septum-seal for sample extraction.

Glass Marking Pen - For labeling vials.

Laboratory Timer - For use during the extraction process.

Vials - 2 dram septum-seal for extract storage.

Pipets - Assorted: 1 mL, 5 mL, 10 mL; disposable glass.

Refrigerator - Separate for sample and standard storage. Capable of maintaining a stable temperature of 4bC.

5.7.5 Reagents

Hexane - Pesticide grade or equivalent.

Neat Standards - 96 percent purity or better for each compound of interest.

Zero-Grade Nitrogen - As carrier gas for the gas chromatograph (GC).

5.7.6 Calibration

Standards. A singular calibration standard for each PCB compound is prepared from commercially purchased standards or pure compound. All standards are made and/or diluted using hexane and are created for use via a 2 µL injection. A working calibration standard concentration of 0.375 ng/µL for each Aroclor is usually practical.

Peak Identification. Each PCB compound is identified by its unique pattern (fingerprint). The identity of each target Aroclor is substantiated by the singular analysis of each individual Aroclor.

Calibration. Calibration of the analytical system is achieved via the external standard method in which response factors (RF) for each individual Aroclor are obtained by the analysis of a standard of known concentration. For each Aroclor analyzed, the responses of several peaks characteristic to that particular Aroclor are summated. Following the analysis of this known standard, a file is created noting each Aroclor's pattern (i.e., the retention times of each characteristic peak), the appropriate RF and known concentration. The RF for each Aroclor is determined by dividing the Aroclor's known concentration by the summated peak responses (area or height units) which were taken from the associated pattern. The concentration of PCB contaminants in samples is usually hand calculated by manually summating the responses of the characteristic peaks and comparing them to the analogous summated peaks designated in the Aroclor standard.

Continuing Calibration - Calibration of the analytical system is performed three times daily: (1) preceding the daily analyses, (2) mid-day, and (3) after the daily analyses. Continuing calibration should be conducted at a concentration level equal to the reported detection limits.

5.7.7 Sample Preparation

All samples must be extracted prior to chromatographic analysis. A suggested protocol for hexane extraction follows:

- Pipet 20 mL aqueous sample matrix into a 40 mL septum-seal vial; discard pipet.

- Add 2.0 mL hexane to the measured matrix aliquot.
- Cap the vial and shake vigorously for 2 minutes.
- Set the vial aside and allow the contents to settle for 5 minutes.
- Pipet off the supernatant extract into a labeled 2-dram septum-seal vial.
- Gas chromatographic analysis is performed by directly injecting 2-5 µL of sample extract onto the GC's analytical column.

5.7.8 Gas Chromatography

Sample contaminants are first stripped from the matrix by means of hexane extraction (see Subsection 5.7.7). A 2-5 µL aliquot of the sample extract is introduced onto the head of a previously conditioned analytical column by means of direct injection technique. The PCB compounds are resolved isothermally due to the affinity the PCB components have for the phases of the column's packing as they migrate (under flow) through the analytical column. As the contaminants elute from the column, they are recognized by an electron capture detector (ECD). Detector signals are then processed by an integrator. As long as analytical conditions remain constant, each PCB pattern will elute at characteristic retention times (RT). In this manner, sample contaminants are identified and quantified by comparison to a run of standards of known concentration.

The following run conditions have been found to be practical for the analysis of PCB compounds analyzed by field screening techniques:

Run Parameter	Setting
Injection Port Temperature	280bC
Isothermal Oven Temperature	215bC
Detector Temperature	300bC
Carrier Gas Flow	30 mL/minute

Under these conditions, Aroclor-1260 will elute within 35 minutes.

Appropriate quantitation of sample contaminants is based upon the following formula:

$$\text{Concentration}\ (\mu g/L)\ =\ \Sigma\ \text{designated peak responses (sample)}\ x\ RF\ x\ DF$$

$$\text{where : RF (Response Factor)}\ =\ \frac{\text{Concentration standard}}{\Sigma\ \text{designated peak responses std.}}$$

DF (Dilution Factor) is used when applicable

5.8 <u>Field Screening of Polychlorinated Biphenyl (PCB) Compounds (Solid Matrix)</u>

5.8.1 Overview

The following methodology describes a modification of SW846 Methods suitable for the determination of polychlorinated biphenyl (PCB) contaminants in solid matrix samples.[6] Via this methodology, a 5 gram portion of solid sample is extracted using rapid field techniques. A µL aliquot of sample extract is then directly injected onto an analytical column for the isothermal resolution of target components. The PCB pattern is recognized by an electron capture detector (ECD) with detector signals processed by a previously programmed integrator (see Figure 4 for a list of Potential Target Compounds).

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[6] (SW846 Methods 3550B, 3580A, and 8082).

5.8.2 Summary of Methods

Low Level Analysis - Use of a 5 gram portion of sample matrix is suggested to achieve method detection limits of approximately 100 µg/kg.

Medium Level Analysis - Sample dilutions are achieved by diluting a portion of the sample extract (as above) in an appropriate volume of hexane.

5.8.3 Interferences

Interferences inherent to this procedure stem from four major sources: (1) impurities present in the solvents used for extraction, (2) system artifacts caused by insufficient column conditioning (3) residual contamination remaining on improperly cleaned glassware and (4) matrix interferences caused by co-extracted organic matter.

Interferences in the analytical system are monitored by the analysis of method blanks. Method blanks are analyzed under the same conditions and at the same time as standards and samples, in order to establish average background response.

Artifacts (which manifest themselves as carryover in the next analytical run) can also occur within the analytical apparatus whenever a highly contaminated sample is introduced. To preclude this, injection syringes are repeatedly flushed with solvent and the analytical column is baked for a short period of time following each direct injection analysis.

5.8.4 Major Apparatus and Materials

In addition to the equipment listed in Subsection 5.7.4, the following device is required:

Oven - Constant temperature for use in the determination of moisture content.

5.8.5 Reagents

Methanol - Pesticide grade or equivalent.

Hexane - Pesticide grade or equivalent.

Neat Compounds - 96 percent purity or better for each Aroclor of interest.

Organic-Free Water - Laboratory supplied or purchased.

Zero-grade Nitrogen - As carrier gas for the gas chromatograph (GC).

5.8.6 Calibration

Standard preparation, compound identification, integration and continuing calibration are accomplished as outlined in Subsection 5.7.6.

5.8.7 Sample Preparation

All samples must be extracted prior to chromatographic analysis. A suggested protocol for hexane extraction follows:

- Weigh and tare a 40 mL septum-seal vial using an analytical balance.
- Add 5.0 grams of sample matrix to the vial; record weight.
- Pipet approximately 1.5 mL of organic-free water into the vial. (The water serves as a wetting agent thus facilitating the transference of the PCB compounds from the soil matrix into the methanol.)
- Pipet approximately 2 mL of methanol into the vial.
- Pipet 2.5 mL of hexane into the vial. (By preference, the PCB compounds almost exclusively partition into the hexane.)
- Cap the vial and shake vigorously for 2 minutes (alternately, vial contents may be sonicated).
- Pipet off the supernatant extract into a labeled 2 dram septum-seal vial.
- Gas chromatographic analysis is performed by directly injecting 2-5 µL of sample extract onto the GC's analytical column.

5.8.8 Gas Chromatography

The same chromatographic theory and GC run conditions outlined in Subsection 5.7.8 are applicable to the PCB analysis of solid matrix samples, with one modification.

Due to the need to correct the final value for moisture content, the quantitation of PCB contaminants in solid matrix samples is calculated based upon the following formula:

$$\text{Concentration } (\mu g/kg) = \Sigma \text{ designated peak responses (sample) x RF x 1/wt. of sample extract(g) x final volume (mL) x 1/\% solids}$$

$$\text{where: RF (Response Factor)} = \frac{\text{Concentration Standard}}{\Sigma \text{ designated peak responses std.}}$$

$$\% \text{ solids} = 100 - \% \text{ moisture}$$

$$\% \text{ moisture} = \frac{\text{Wet wt.} - \text{Dry wt.}}{\text{Wet wt.}} \times 100$$

The protocol for determining percent moisture is presented in Subsection 5.12.

5.9 Field Screening Analysis of Ambient Air

5.9.1 Overview

The following methodology describes a modification of EPA Compendium methods suitable for the determination of volatile organic contaminants in ambient air.[7] Via this methodology, an aliquot of gaseous sample is routed through a packed sorbent tube. Volatile contaminants present in the gaseous

[7] (EPA Compendium Methods TO-1, TO-2, TO-3, and TO-12).

sample are adsorbed onto the packing within the sorbent tube. The contents of the sorbent tube are subsequently desorbed (by action of heat and reverse gas flow) onto a suitable column housed by a pre-programmed gas chromatograph (GC). The contaminants become separated and resolved as they travel through the GC's column. Eventually, the contaminants elute through an appropriate detector. Detector signals are processed and interpreted via a previously programmed integrator (see Figure 1 for a list of Potential Target Compounds).

5.9.2 Summary of Method

The procedure described here is based upon the analysis of whole air samples collected in canisters or Tedlar bags. However, this procedure can easily be adapted for the analysis of samples collected directly on sorbent tubes or for source sample analysis using aliquot introduction into the GC via direct gaseous injection or an appropriate size commercial sample loop.

5.9.3 Interferences

Interferences can result from many sources, considering the environmental settings of most hazardous waste sites. However, most interfering impurities are artifacts originating from organic compounds within the specialty gases and the plumbing within the trapping/desorption device. Interferences in the analytical system are monitored by the analysis of inert gas method blanks. Method blanks are analyzed under the same conditions and at the same time as standards and samples, to establish an average background response.

5.9.4 Major Apparatus and Materials

Purge and Trap Device - Tekmar Model LSC-2 or Model 5000. Traps may be packed solely with Tenax or alternately, trap packing may consist of 1.0 cm of 3 percent OV-1, 15 cm of Tenax and 8 cm of silica gel. Appropriate trap selection is contingent upon the target compounds being analyzed.

Gas Chromatograph - Hewlett Packard 5890 or equivalent. The analytical system should be equipped for temperature programming, packed and/or capillary column analysis and on-column injection.

Detector - PID/FID or PID/HECD in series; FID only. Optimum detector selection should be based upon the sensitivities of the target compounds being analyzed.

Analytical Column - Glass or stainless steel packed with 1 percent SP-1000 on 60/80 mesh Carbopack B. Alternately a suitable capillary column may be used.

Syringes - Assorted: 5 µL, 25 µL, 100 µL, 1 mL, 10 mL.

Volumetric Flasks - 10 mL, 25 mL, 100 mL.

Tedlar Bag - For making gaseous standards.

Flow Meter - For use in measuring the exact volume of gas introduced to the Tedlar.

Analytical Balance - Capable of accurately weighing 0.0001 g.

Vacuum Pump - Low draw, positive seal.

Refrigerator - Separate for sample and standard storage. Capable of maintaining a stable temperature of 4bC.

5.9.5 Reagents

Methanol - Pesticide grade or equivalent.

Organic-Free Water - Supplied by laboratory or purchased.

Neat Solvents - 96 percent purity or better for each compound of interest.

Ultra-high Purity Nitrogen - For use in generating standards and method blanks.

5.9.6 Calibration

Standards. Calibration standards containing the compounds of interest are prepared in methanol by either diluting commercially purchased stock standard mixes or by creating in-house standards from pure solvents. In-house calibration standards are prepared gravimetrically, in that an appropriate µL aliquot of each target compound is introduced into a known volume of methanol. The appropriate µL aliquot of compound is based upon the compound's density and response to the selected detector. The calibration standards should be created at such a level that a 5-10 µL spike into a 1 liter Tedlar bag filled with nitrogen yields a concentration of 10 µg/L based upon the analysis of a 500 mL aliquot. Aliquots are evacuated onto a clean trap. Alternately, commercially prepared stock calibration gases may be used.

Peak Identification. Compound identities may be substantiated by the analysis of each individual component thereby documenting compound retention time.

Initial Linearity. An initial three-point calibration curve is generated by the trapping and analysis of multiple aliquots of calibration standard. For example, if the calibration standard is created such that analysis of a 500 mL aliquot of standard yields results at the level of the reported detection limits, a three-point calibration curve may be achieved by the analysis of 500, 700 and 1,000 mL aliquots.

Integration. Calibration of the analytical system is achieved via the external standard method in which response factors (RF) for each compound are obtained by the analysis of a standard mix of known concentration. Following the analysis of this known standard mix, an electronic file is created establishing each peak's identity, retention time, RF, and known concentration. The RF for each target compound is determined by dividing the known concentration by the associated peak response (area or height units). For initial calibration, each compound's average response factor is determined by averaging the peak response results generated for the initial linearity study. These average response factors are programmed into the integrator to allow for direct concentration reading of contaminants found in subsequent sample analyses.

Continuing Calibration. Calibration of the analytical system should be updated three times daily: (1) preceding the daily analysis, (2) mid-day and (3) after the daily analyses. Continuing calibration should be conducted at a concentration level equal to the reported detection limits.

5.9.7 Gas Chromatography

Preconcentration of sample contaminants is achieved through the trapping process in which the volatile contaminants are adsorbed on to a sorbent trap. The affinity that the volatilized organic contaminants have for the special packing inside the sorbent tube cause them to be retained within the tube (i.e., adsorbed onto the packing) while other components of the gaseous aliquot pass through the tube.

Desorption of the adsorbed contents of the sorbent trap onto the head of a previously conditioned GC analytical column allows for subsequent analysis by temperature-programmed gas chromatography. The desorbed contaminants are first held at constant temperature (usually in the range of 45-55bC) at the head of the analytical column for a period of 3-5 minutes. After this initial time period, the GC oven temperature is raised at a constant rate (usually 8-15bC/minute) until a final temperature of 200-225bC is reached. The final temperature is customarily held for a period of 3-10 minutes.

The preferential affinity of the volatile contaminants to either the analytical column's mobile or stationary phase, the effect of elevated temperature and the action of carrier gas flow through the column cause the volatile contaminants to become separated and resolved allowing them to elute in bands through the selected detector. As long as analytical conditions remain constant, each type of volatile component will elute at a characteristic retention time (RT). In this manner, sample contaminants are identified and quantified by comparison to a run of standard of known concentration.

The quantitation of volatile contaminants is calculated based upon the following formula:

$$\text{Concentration sample } (\mu g/L) = \text{Target peak response (sample)} \times RF \times DF$$

$$\text{where : } RF \text{ (Response Factor)} = \frac{\text{Target concentration standard } (\mu g/L)}{\text{Target peak response std.}}$$

DF (Dilution Factor) is used when applicable

5.10 Field Screening Analysis of Volatile Contaminants in Soil Gas Matrix

5.10.1 Overview

The following methodology describes a modification of SW846 and EPA Compendium methods as applied to the determination of volatile organic contaminants in soil gas.[8] Via this methodology, a sorbent tube containing previously trapped volatile organic contaminants obtained via the sampling of soil gas matrix, is subsequently desorbed (by action of heat and reverse gas flow) onto a suitable analytical column housed by a pre-programmed gas chromatograph (GC). The volatile organic contaminants become separated and resolved as they travel through the GC's column. Eventually, the contaminants elute through an appropriate detector. Detector signals are processed and interpreted via a previously programmed integrator. Figure 1 provides a list of Potential Target Compounds.

5.10.2 Interferences

Interferences can result from many sources, considering the environmental settings of most hazardous waste sites. However, most interfering impurities are artifacts originating from organic compounds within the specialty gases and the plumbing within the trapping/desorption device. The presence of air molecules and excessive water vapor and/or the degradation of the trap packing can also account for many artifacts.

Interferences in the analytical system are monitored by the analysis of inert gas method blanks. Method blanks are analyzed under the same conditions and at the same time as standards and samples, to establish an average background response.

[8] (SW846 Method 5041A; EPA Compendium Methods TO-1, TO-2, TO-3, and TO-12).

5.10.3 Major Apparatus and Materials

Purge and Trap Device - Tekmar Model LSC-2 or Model 5000. Traps may be packed solely with Tenax or, alternately, trap packing may consist of 10 cm of 3 percent OV-1, 15 cm of Tenax and 8 cm of silica gel. Appropriate trap selection is contingent upon the target compounds being analyzed.

Gas Chromatograph - Hewlett Packard 5890 or equivalent. The analytical system should be equipped for temperature programming, packed and/or capillary column analysis, and on-column injection.

Detector. PID/FID or PID/HECD in series; FID only. Optimum detector selection should be based upon the sensitivity to the detector for the target compounds being analyzed.

Analytical Column. Glass or stainless steel packed with 1 percent SP-1000 on 60/80 mesh Carbopack B. Alternately a suitable capillary column may be used.

Syringes - Assorted gas tight 5 µL, 25 µL, 100 µL, 1 mL, 10 mL.

Volumetric Flasks - 10 mL, 25 mL, 100 mL.

Tedlar Bags - For making gaseous standards.

Flow Meter - For use in measuring the exact volume of gas introduced to the Tedlar bag.

Analytical Balance - Capable of accurately weighting 0.0001 g.

Vacuum Pump - Low draw, positive seal.

Refrigerator - Separate for sample and standard storage. Capable of maintaining a stable temperature of 4bC.

5.10.4 Reagents

Methanol - Pesticide grade or equivalent

Organic-Free Water - Supplied by laboratory or purchased.

Neat Solvents - 96 percent purity or better for each compound of interest.

Ultra-high Purity Nitrogen - For use in generating standards and method blanks.

5.10.5 Calibration

Standard. Calibration standards containing the compounds of interest are prepared in methanol by either diluting commercially purchased stock standard mixes or pure solvents. In-house calibration standards are prepared gravimetrically in that a µL aliquot of each target compound is introduced into a known volume of methanol. The appropriate µL aliquot of compound is based upon the compounds density and response to the selected detector. The calibration standards should be created at such a level that a 5-10 µL spike into a 1-liter Tedlar bag filled with nitrogen yields a concentration of 10 µg/L based upon the analysis of a 500 mL aliquot. Aliquots are evacuated onto a clean trap. Alternately, commercially prepared stock calibration gases may be used.

Peak Identification. Compound identities may be substantiated by the analysis of each individual component thereby documenting compound retention time.

Initial Linearity. An initial three-point calibration curve is generated by the trapping and analysis of multiple aliquots of calibration standard. For example, if the calibration standard is created such that analysis of a 500 mL aliquot of standard yields results at the level of the reported detection limits, a three-point calibration curve may be achieved by the analysis of 500, 700 and 1,000 mL aliquots.

Integration. Calibration of the analytical system is achieved via the external standard method in which response factors (RF) for each compound are obtained by the analysis of a standard mix of known concentration. Following the analysis of this known standard mix, an electronic file is created establishing each peak's identity, retention time, RF, and known concentration. The RF for each target compound is determined by dividing the known concentration by the associated peak response (area or height units). For initial calibration, each compound's average response factor is determined by averaging the peak response results generated for the initial linearity study. These average response factors are programmed into the integrator to allow for direct concentration reading of contaminants found in subsequent sample analyses.

Continuing Calibration. Calibration of the analytical system should be updated three times daily: (1) preceding the daily analysis, (2) mid-day, and (3) after the daily analyses. Continuing calibration should be conducted at a concentration level equal to the reported detection limits.

5.10.6 Sample Preparation

Prior to the desorption and analysis of previously trapped soil gas contaminant tubes, the introduction of a surrogate spike compound via a short purge is recommended. In addition to enhancing quality assurance, this short purge cycle allows inert gas molecules to replace potentially destructive air molecules still entrained within the trap tube. The surrogate spike compound should be introduced to the trap via the following procedure:

- Program the Tekmar LSC-2 device for a 3 minute purge, 3 minute desorb and 8 minute bake cycle.
- Insert a previously trapped soil gas contaminant tube.
- Spike 2 µL of an appropriate surrogate spike solution (such as 1 µg/µL 2-bromo-1-chloropropane) into a glass sparge vessel containing 20 mL organic-free water.
- Purge the surrogate spike onto the trap. Desorb and analyze.

5.10.7 Gas Chromatography

Preconcentration of soil gas matrix contaminants is achieved through the sampling process in which the volatile contaminants are adsorbed onto the sorbent trap. The affinity that the volatile organic contaminants have for the special packing inside the sorbent tube cause them to be retained within the tube (i.e., adsorbed onto the packing) while other components of the gaseous matrix pass through the tube.

Following the addition of a surrogate spike compound, the adsorbed contents of the sorbent trap are desorbed (by action of heat and reverse gas flow) onto the head of a previously conditioned GC analytical column. The desorbed contaminants are first held at constant temperature (usually between 45-55bC) for an initial time period of 3-5 minutes. The desorbed contaminants are subsequently analyzed by temperature-programmed gas chromatography in which, following the initial hold, the GC oven temperature is raised at a constant rate (usually 8-15bC/minute) until a final temperature of 200-225bC is reached. The final temperature is customarily held for a period of 3-10 minutes.

The preferential affinity of the volatile contaminants to either the analytical column's mobile or stationary phase, the effect of elevated temperature and the action of carrier gas flow through the column cause the volatile contaminants to become separated and resolved allowing them to elute in bands through the selected detector. As long as analytical conditions remain constant, each type of volatile component will elute at a characteristic retention time (RT). In this manner, sample contaminants are identified and quantified by comparison to a run of standard of known concentration.

The quantitation of volatile contaminants is calculated based upon the following formula:

$$\text{Concentration sample } (\mu g/L) = \text{Target peak response (sample)} \times RF \times DF$$

$$\text{where : } RF \text{ (Response Factor)} = \frac{\text{Target concentration standard } (\mu g/L)}{\text{Target peak response std.}}$$

DF (Dilution Factor) is used when applicable

5.11 Quality Assurance/Quality Control (QA/QC)

5.11.1 Overview

Field screening generates Level II data. As Level II data, the concurrent analysis of laboratory duplicates and matrix spike analyses and the use of surrogate spike compounds is not required. However, beyond the maintenance of practical Standard Operating Procedures (SOPs), certain elements of quality control (if opted) can greatly enhance the interpretation of and the confidence in the data generated. These traditional elements of quality control are discussed here with respect to how they are adapted to meet the demands of a successfully applied field screening QA/QC program.

The primary purposes of an appropriate QA/QC program are to: (1) substantiate system performance and give credence to the accuracy of the results generated, (2) to define aberrations and give guidance to the interpretation of data, and (3) to achieve these goals through realistic efforts that do not impede the forward progress of the analytical set.

The discussion presented here deals with only direct analytical quality control. Additional elements of QA/QC, such as field duplicate sample submissions, blind spike analysis and external audits are not discussed. Also not discussed are elements of QA/QC that are inherent to good chromatographic technique. Examples of these accepted laboratory practices include (but are not limited to) the following:

- The proper conditioning of analytical columns and traps.
- Use of the solvent flush technique for the creation of standards and for direct injections.
- The appropriate maintenance of selected detectors.

Details regarding these accepted practices are given in the referenced methodologies.

5.11.2 Holding Times

The primary purpose of field screening is to provide cost-effective, specific data on a near- to real-time turn-around basis. For this reason, samples submitted to the mobile laboratory should be analyzed as soon as possible. Samples awaiting analysis are stored at 4bC in a dedicated refrigerator. If, because of loading, it is not possible to analyze all samples taken daily, the following holding times are suggested:

Type of Sample	Holding Time
VOA (aqueous matrix)	7 days prior to analysis
VOX (soil matrix)	10 days prior to analysis
SEMI, PEST, and PCB (aqueous matrix)	5 days prior to extraction; analysis within 30 days
SEMI, PEST, and PCB (soil matrix)	5 days prior to extraction; analysis within 30 days

5.11.3 Sample Sets

Analyses should be conducted in sets of ten, whenever possible, with one laboratory duplicate spike analysis run per set. Each set of sample analyses should be bracketed by the analysis of a standard, with a method blank analysis following each standard run.

The number of analyses per sample set and the associated QA/QC varies per contract. The project work plan/QAPP should be consulted to verify that all contractual obligations are met.

5.11.4 Continuing Calibration

Standards run for continuing calibration purposes should be analyzed at a level equal to the reported detection limits. Continuing calibration response factors for each parameter should fall within 25 percent difference (D) of the average response factor calculated for that particular compound during the initial linearity study (see Figure 5). Data associated with individual parameter not meeting the 25 percent D criteria should be flagged as suspect.

5.11.5 Laboratory Duplicates

One laboratory duplicate should be analyzed per sample set. Laboratory duplicate analyses should generate results within 30 percent RPD (see Figure 5).

5.11.6 Matrix Spike Analyses

Matrix spikes should be conducted at a level of 1-4 times the concentration of the reported detection limits. One matrix spike analysis should be run per every 20 samples. Advised recovery ranges vary with respect to the compound being analyzed. Recoveries of 35-150 percent are generally acceptable (see Figure 5).

5.11.7 Surrogate Spikes

The use of at least one surrogate spike compound is highly recommended. The identity, concentration and addition of the appropriate surrogate spike varies with the procedure being used. Each associated referenced methodology should be consulted for guidance. Surrogate spike recoveries should fall within ?30 percent (see Figure 5). Sample analyses yielding recoveries outside this 30 percent window should be reanalyzed or the associated data should be flagged as suspect.

5.11.8 Initial Linearity

An initial linearity study is performed as described in each adapted methodology. The associated response factors should all fall within <20 percent RSD (see Figure 5). Standard runs yielding data that does not meet the <20 percent RSD criteria should be reanalyzed.

5.11.9 Method Blanks

Method blanks are prepared and analyzed in exactly the same manner as sample matrices. A method blank analysis should follow every standard run and sample of high concentration. Ideally, method blank results should yield no interferences to the chromatographic analysis and interpretation of target compounds. If interferences are present, associated data should be qualified as suspect and/or target detection limits should be adjusted accordingly.

5.11.10 Detection Limits

The appropriate method detection limit (MDL) for an adapted methodology may be statistically calculated using results generated for the initial linearity study and continuing calibrations, or, method detection limits may be substantiated by the analysis of a low standard at the level of the anticipated MDL.

5.12 Supplemental Protocol: Percent Moisture Determination

A moisture correction factor (MCF) is used to adjust the value generated for the amount of contaminant present in a solid matrix sample, so that the value reflects the true (dry weight) concentration of contaminant. Moisture content is determined gravimetrically. The following protocol is suggested for determining percent moisture:

- Mark and weigh an aluminum tare using an analytical balance. Record weight; tare balance.
- Place 5-10 grams of matrix (free from unrepresentative pebbles and organic matter) into the pan; record weight.
- Place the pan and its contents into a drying oven heated to 103bC.
- Dry the matrix for a period of 4-6 hours (or until weight is constant).
- Remove the pan from the oven and allow to cool to room temperature.
- Weigh the pan and record the weight.
- Calculate percent moisture and the MCF.

5.13 Supplemental Protocol: Field Screening Validation

The validation process serves as an independent check thus ensuring the proper performance of all QA/QC measures. Figures 6 and 7 illustrate a validation protocol that is suitable for the evaluation of field screening data.

6.0 REFERENCES

"Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater," EPA-600/4-82-057. (EPA 600 Series methods):

FIGURE 5

QC COMPUTATIONS

$$\%\,RSD\ (\text{Relative Standard Deviation}) = \frac{SD}{X} \times 100$$

$$\text{where}: \quad SD = \sum_{i=1}^{N} \frac{(x_i - x)^2}{N - 1}$$

X = mean of initial four response factors (per compound)

$$\%\,RPD\ (\text{Relative Percent Difference}) = \frac{D_1 - D_2}{(D_1 + D_2)/2} \times 100$$

where: D_1 = First Sample Value

D_2 = Second Sample Value

$$\%\,D\ (\text{Percent Difference}) = \frac{X_1 - X_2}{X_1} \times 100$$

where: X_1 = RF (Response Factor) of first result

X_2 = RF of Second Result

$$\%\,R\ (\text{Percent Recovery}) = \frac{SSR - SR}{S} \times 100$$

where: SSR = Spike Sample Results

SR = Sample Result

S = Amount of Spike Added

FIGURE 6

TtNUS/FIELD SCREENING

VALIDATION PROTOCOL

1. Verify that samples were handled in sets of ten or less.
2. Verify that at least one laboratory duplicate was run once every ten samples.
3. Verify that one matrix spike analysis was performed once every 20 samples.
4. Ensure that at least one surrogate spike compound was used.
5. Substantiate daily initial calibration table.
6. Determine if at least one standard was run every 8 hours and that a calibration standard was run after every set of ten samples (plus QC runs).
7. Check standard tracking form to ensure that parameter response factors fall within 25 percent of the initial calibration. If parameters exceed 25 percent value, check to see how problem was corrected and verify all reported results for that parameter were flagged as suspect.
8. Check that method blanks were run after every calibration and every sample of high concentration. Verify that any system artifacts were tracked and reported.
9. Verify that reported detection levels have been properly substantiated.
10. Evaluate chromatograms of target compound peaks for proper identification. (Check peak shapes and shoulders.)
11. Check quantitations of approximately 20 percent of samples.
12. Verify if statistics have been calculated for the data package.
13. Verify retention time window.
14. Determine if each chromatogram reports the following information:

    a. Sample name/number
    b. Date/time of analysis
    c. Laboratory duplicate designation (if applicable)
    d. Matrix spike designation (if applicable)
    e. Concentration/dilution value recorded (if applicable)
    f. Retention time reported at apex of each peak
    g. Chromatographic report generated includes peak name, retention time, peak area or peak height.

FIGURE 6
TtNUS/FIELD SCREENING
<u>VALIDATION PROTOCOL</u>
PAGE TWO

15. Verify that package Operations Record contains the following information:

    a. Purge, desorb, and bake time of sample concentrator

    b. GC flow rate, attenuation, range, initial temperature, initial time, ramp, final temperature, final time; injection temperature and detector temperature.

16. Verify that chain of custody was maintained.

17. Verify that package narrative relates all pertinent information necessary to properly interpret results.

FIGURE 7

TtNUS/FIELD SCREENING

VALIDATION RECORD

Project Name/Number: ____________________ Sample Matrix: ____________________

Dates Samples Received: ____________________ Data Reviewer: ____________________

Dates Samples Analyzed: ____________________ Data Reviewed: ____________________

Evaluation Checklist:

_______ Data Completeness

_______ Calibration Records

_______ Method Blank Analyses

_______ Surrogate Spike Results

_______ Duplicate Analyses Results

_______ Matrix Spike Recoveries

_______ Compound Identification

_______ Detection Limits Achieved

Reviewier's Evaluation	Volatiles	Acids	Base/Neutrals	PCBs/Pesticides
Acceptable				
Acceptable with Exception(s)				
Questionable				
Unacceptable				

Validator's Comments:

Method	Title
601	Purgeable Halocarbons
601	Purgeable Aromatics
604	Phenols
606	Phthalate esters
608	Pesticides and PCBs
610	Polynuclear Aromatic Hydrocarbons
612	Chlorinated Hydrocarbons
624	Purgeables
625	Base/Neutrals, Acids, and Pesticides

"Test Methods for the Evaluation of Solid Waste," SW-846, EPA Publication No. 955-001-00000-1. (SW846 preparative methods):

Method	Title
5030B	Purge and Trap Technique for Aqueous Samples
5041A	Protocol for Analysis of Sorbent Cartridges
3580A	Waste Dilution
5035	Purge and Trap and Extraction for VOCs in Soil and Waste Samples

"Test Methods for the Evaluation of Solid Waste," SW846, EPA Publication No. 955-001-00000-1. (SW846 analytical methods):

Method	Title
8015	Non-halogenated Volatile Organics
8021B	Aromatic and Halogenated Volatile Organics
8041	Phenols
8061	Phthalate Esters
8081A	Organochlorine Pesticides
8100	Polynuclear Aromatic Hydrocarbons
8121	Chlorinated Hydrocarbons
8260B	GC/MS for Volatile Organics
8270C	GC/MS for Semi-volatile Organics (Capillary Column)
8310	Polynuclear Aromatic Hydrocarbons
8082	Polychlorinated Biphenyls

"Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air," EPA-600/4-84-041.

Method	Title
TO-1	Tenax GC Adsorption
TO-2	Carbon Molecular Sieve Adsorption
TO-3	Cryogenic Trapping
TO-12	NMOC in Ambient Air Using Preconcentration and FID

"Field Measurement of PCBs in Soil and Sediment Using a Portable Gas Chromatograph," Spittler, Dr. Thomas. U.S. EPA Region I.

"Comparability of Field Screening Data to Fixed-base Laboratory Results," Scheib, Debra A., Dr. H. Roffman and C. Kieda. NUS Corporation.

"Manual of Field Analytical Technique," Scheib, Debra A. NUS Corporation.

7.0 RECORDS

A formalized system for tracking and reporting information is essential to appropriately document the specific analytical approach used to support the investigation of a hazardous waste site. Sound record keeping practices serve to:

- Document the QA/QC measures performed.
- Substantiate sample integrity.
- Present data in a usable form.
- Organize and record the occurrences pertinent to the interpretation of the data generated.
- Function as the historical record leading to the development of new methodologies and for the improvement of existing methods.

In light of the advances in laboratory automation and computer technology, record keeping can take the form of either electronic file or bench data sheets. Regardless of the method of record keeping employed while in the field, the submission (to the Project Manager) of a formalized, hard-copy data package upon conclusion of the field screening activity is strongly recommended. Examples of useful bench data sheets not already presented in this text follow as Figures 8 through 20. A suggested Table of Contents (Figure 21) and data package Cover Sheet (Figure 22) are also presented.

Mobile laboratory facilities vary greatly in design. Consequently, in addition to the maintenance of pertinent records, a site-specific S.O.P. (Standard Operating Procedure) should be developed to provide the following:

- Specific information regarding the operation and maintenance of the particular affiliated instrumentation.
- Guidance regarding the hook-up of power and other necessary services.
- Procedures addressing the disposal of laboratory waste.
- Materials and supply resources.
- Towing and transport considerations.
- Housekeeping requirements.

FIGURE 8
TtNUS/FIELD SCREENING
PROJECT SUMMARY REPORT

Compound	Target Detection Limits	Sample Number						
DILUTION								
DATE SAMPLED								
DATE ANALYZED								
REPORT NUMBER								
COMMENTS								

FIGURE 9

TtNUS/FIELD SCREENING

DATA QUALIFIERS

B	-	found in blank
DL	-	detection limit
DNI	-	peak "did not integrate;" quantitation is not possible
J	-	estimated quantity
u	-	compound analyzed for but value generated is below reported DL
U	-	GC peak over range. Peak exceeds linear range of detector and is not quantifiable
( )	-	compound present, but detected at levels below the reported DL

CHROMATOGRAM NOTATIONS

ART	-	artifact; peak produced by chromatographic system, not caused by sample content
au	-	area units
D	-	laboratory duplicate
hu	-	height units
MB	-	method blank
MS	-	matrix spike
NEAT	-	sample is not diluted
FD	-	field duplicate

FIGURE 10

TtNUS/FIELD SCREENING
OPERATIONS RECORD

General Information:

Date(s)	______________	Task Name	______________	Std Used	______________
Site Name	______________	Task No.	______________	Analyst	______________
Site No.	______________	Matrix	______________		

Chromatographic Programming:

Flow	_______	In. Temp.	______________	Inj. Temp.	______________
Attn	______________	In. Time	______________	Det. Temp.	______________
Range	_______	Rate	______________	Other	______________
Col.	______________	Fin. Temp.	______________	____________________________	
Detector	___________	Fin. Time	______________	____________________________	

Integration System:

File	______________	Speed	______________	Other
Attn	______________	Zero/Slope	______________	_____________________
Range	______________	Min. Area	______________	_____________________
Method	______________	Stop Time	______________	_____________________
Format	______________	____________________________		_____________________

Purge/Desorption System:

Purge Time	______________	SP-2	______________	Prepurge	_______
Desorb	______________	SP-3	______________	Preheat	_______
Bake Time	______________	SP-4	______________	Purge Temp.	_______
SP-1	______________	SP-5	______________	Line Temp.	_______

Comments:

____

____

____

FIGURE 11

TtNUS/FIELD SCREENING ANALYTICAL STANDARDS LOG

Target Compound	Desired Final Concentration*	Matrix Amount	Required Dose	Desired Standard Injection	Required Standard Concentration	Volume of Standard	Compound Density	Calculation	Amount Neat Compound
Example: Trichloroethene	3 ppb	20 mL	0.06 µg/L	2 µL	0.03 µg/µL	50,000 µL	1,465 µg/µL	µL = {0.03 µg/µL x 50,000 µL} ÷ 1,465 µg/µL	1.02

*Example: $\frac{3\ \mu g}{L} = \frac{3\ \mu g}{1{,}000\ mL} = 0.06\ \mu g$ per 20 mL

Therefore, 0.06 µg per 2 µL injection of standard.

Therefore, standard concentration must equal 0.03 µg/µL.

Formula: $\text{Neat Solvent } (\mu L) = \frac{\text{Required Std. Concentration } (\mu g/L) \times \text{Volume of Std. } (\mu L)}{\text{Compound Density } (\mu g/\mu L)}$

Check: $1.02\ (\mu L) \times \frac{1{,}494\ \mu g}{\mu L} = \frac{1{,}494\ \mu g}{5{,}000\ \mu L} \times 2\ \mu L = \frac{0.0598\ \mu g}{20\ mL} \times \frac{1{,}000\ mL}{L} = 2.99$ ppb

FIGURE 12

TtNUS/FIELD SCREENING

3-POINT INITIAL CALIBRATION

DATE: ______________________ **INSTRUMENT:** ______________________

ANALYST: ______________________ **COLUMN:** ______________________

Compound	Standard I.D. Number	Standard Concentration	Response	Response Factor	^{x}RF	^{s}RF	%RSD

FIGURE 13

TtNUS/FIELD SCREENING

CONTINUING CALIBRATION SUMMARY
VOLATILES

Retention Time	Parameter	Concentration of Standard Injection	Analysis Date										
			Analysis Time										
			Average RF (Initial Calib.)	%D		%D		%D		%D		%D	

Response Factor (RF) tracking, where $RF = \frac{\text{Concentration}}{\text{Peak response}}$ - Quality Control Criteria:

%D between average initial RF and continuing calibration RF must not exceed ±25%, where $\%D = \frac{\text{initial average RF - continuing calibration RF}}{\text{initial average RF}} \times 100$

FIGURE 14
TtNUS/FIELD SCREENING

METHOD BLANK SUMMARY (OVERVIEW)

By definition, method blanks consist of an equal aliquot of like matrix + surrogate spike. For quality control/troubleshooting purposes, it sometimes becomes necessary to exclude the surrogate spike or run variations of the matrix. In order to avoid confusion, distinctions of various types of blanks are clarified here:

Trip Blank - previously prepared VOA vials filled with organic-free water, sealed and transported with sample containers. These sealed vials are not opened until analysis; their purpose is to ensure no cross contamination (migration of contaminants through the container's seal) has occurred during transit.

Rinsate Blank - a containerized aliquot of bailer or sampler washwater. Ensures appropriate cleaning and rinsing of the sampling equipment.

Prepared Soil Matrix Blank - a laboratory soil matrix blank is prepared by obtaining an amount of soil and baking it in the drying oven overnight at 105bC to drive off volatile organic compounds. An aliquot of prepared matrix is run without surrogate spike to ensure the matrix is free of contaminants.

Aqueous Method Blank - an aliquot of organic-free water + surrogate spike.

Solid Method Blank - an aliquot of prepared soil matrix + surrogate spike.

Water Purge (System Blank) - an aliquot of organic-free water only; no surrogate spike.

Repurge - repurging, trapping and analysis of material run previously in sparging apparatus.

Desorption/Redesorption - desorb and analysis of trap without any additional purging.

GC Column Only - analysis of GC column response without any prior desorption onto the GC.

Comments regarding the various blank analyses performed for this site appear on the following summary sheets:

FIGURE 15
TtNUS/FIELD SCREENING

METHOD BLANK SUMMARY

FRACTION: ____________________ MATRIX: ____________________

DATE ANALYZED: ____________________ BY: ____________________

INSTRUMENT: ___________________________

Compounds Found	Concentrations	Detection Limit

Comments: ____

____

____

____

FIGURE 16
TtNUS/FIELD SCREENING

LABORATORY DUPLICATE SUMMARY

Sample Number: ______________________________

Matrix: ______________________________

Chromatogram Number: ________________________

Compound	Original Result	Duplicate Result	Percent Difference

$$\text{Percent Difference} = \frac{\text{Original - Duplicate}}{\text{1/2 Original} + \text{Duplicate}} \times 100\%$$

FIGURE 17

TtNUS/FIELD SCREENING

MATRIX SPIKE SUMMARY

Fraction: ____________________ **Sample Number:** ____________________

MS Chromatogram Number: ________________

Matrix Spike Compounds	Original Result	Aliquot	Spike Added	Theoretical[(1)] Result	Matrix Spike	
					Result	MSR%[(2)]

(1) $$\text{Theoretical Result} = \frac{(\text{Original Result} \times \text{Aliquot}) + \text{Spike Added}}{\text{Aliquot}}$$

FIGURE 18
TtNUS/FIELD SCREENING

SAMPLE LOG/RUN ROSTER

Date Received	Project Number	Matrix	Submitted by	Sample Information	Sample Description	Date Analysis	Time Analysis	Analysis Number	Run Number	C/D	Chrom. Number	Analysis Comments

*All analyses performed by: ______________________

Page ______ of ______

FIGURE 19
TtNUS/FIELD SCREENING

SURROGATE RECOVERIES

Chromatogram Number	Sample Designation	Peak Area or Height	%	Chromatogram Number	Sample Designation	Peak Area or Height	%

Surrogate peak response of daily method blank analysis = 100%

$$\text{Sample recovery (\%)} = \frac{\text{sample surrogate response}}{\text{method blank surrogate response}} \times 100$$

FIGURE 20
TtNUS/FIELD SCREENING

CONTENTS

FIGURE 21

COVER SHEET

TtNUS/FIELD SCREENING

Project Number/Name: ____

Analysis/Matrix: ____

Dates: ____

File _____ of _____

TETRA TECH NUS, INC.	STANDARD OPERATING PROCEDURES	Number SA-2.5	Page 1 of 6
		Effective Date 09/03	Revision 3
		Applicability Tetra Tech NUS, Inc.	
		Prepared Earth Sciences Department	
Subject DIRECT PUSH TECHNOLOGY (GEOPROBE®/HYDROPUNCH™)		Approved D. Senovich	

TABLE OF CONTENTS

1.0 PURPOSE

The purpose of this procedure is to provide general reference information on Direct Push Technology (DPT). DPT is designed to collect soil, groundwater, and soil gas samples without using conventional drilling techniques. The advantage of using DPT over conventional drilling includes the generation of little or no drill cuttings, sampling in locations with difficult accessibility, reduced overhead clearance requirements, no fluid introduction during probing, and typical lower costs per sample than with conventional techniques. Disadvantages include a maximum penetration depth of approximately 15 to 40 feet in dense soils (although it may be as much as 60 to 80 feet in certain types of geological environments), reduced capability of obtaining accurate water-level measurements, and the inability to install permanent groundwater monitoring wells. The methods and equipment described herein are for collection of surface and subsurface soil samples and groundwater samples. Soil gas sampling is discussed in SOP SA-2.4.

2.0 SCOPE

This procedure provides information on proper sampling equipment and techniques for DPT. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling techniques. The techniques described shall be followed whenever applicable, noting that site-specific conditions or project-specific plans may require adjustments in methodology.

3.0 GLOSSARY

Direct Push Technology (DPT) - DPT refers to sampling tools and sensors that are driven directly into the ground without the use of conventional drilling equipment. DPT typically utilizes hydraulic pressure and/or percussion hammers to advance the sampling tools. A primary advantage of DPT over conventional drilling techniques is that DPT results in the generation of little or no investigation derived waste.

Geoprobe® - Geoprobe® is a manufacturer of a hydraulically-powered, percussion/probing machines utilizing DPT to collect subsurface environmental samples. Geoprobe® relies on a relatively small amount of static weight (vehicle) combined with percussion as the energy for advancement of a tool string. The Geoprobe® equipment can be mounted in a multitude of vehicles for access to all types of environmental sites.

HydroPunch™ - HydroPunch™ is a manufacturer of stainless steel and Teflon® sampling tools that are capable of collecting representative groundwater and/or soil samples without requiring the installation of a groundwater monitoring well or conventional soil boring. HydroPunch™ is an example of DPT sampling equipment.

Flame Ionization Detector (FID) - A portable instrument for the measurement of many combustible organic compounds and a few inorganic compounds in air at parts-per million levels. The basis for the detection is the ionization of gaseous species utilizing a flame as the energizing source.

Photo Ionization Detector (PID) - A portable instrument for the measurement of many combustible organic compounds and a few inorganic compounds in air at parts-per million levels. The basis for the detection is the ionization of gaseous species utilizing ultraviolet radiation as the energizing source.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for selecting and/or reviewing the appropriate DPT drilling procedure required to support the project objectives.

Field Operations Leader (FOL)- The FOL is primarily responsible for performing the DPT in accordance with the project-specific plan.

5.0 SOIL SAMPLING PROCEDURES

5.1 General

The common methodology for the investigation of the vadose zone is soil boring drilling and soil sampling. However, drilling soil borings can be very expensive. Generally the advantage of DPT for subsurface soil sampling is the reduced cost of disposal of drilling cuttings and shorter sampling times.

5.2 Sampling Equipment

Equipment needed for conducting DPT drilling for subsurface soil sampling includes, but is not limited to, the following:

- Geoprobe® Sampling Kit
- Cut-resistant gloves
- 4-foot x 1.5-inch diameter macrocore sampler
- Probe sampling adapters
- Roto-hammer with 1.5-inch bit
- Disposable acetate liners for soil macrocore sampler
- Cast aluminum or steel drive points
- Geoprobe® AT-660 Series Large Bore Soil Sampler, or equivalent
- Standard decontamination equipment and solutions

For health and safety equipment and procedures, follow the direction provided in the Safe Work Permit in Attachment 1, or the more detailed directions provided in the project's Health and Safety Plan.

5.3 DPT Sampling Methodology

There are several methods for the collection of soil samples using DPT drilling. The most common method is discussed in the following section. Variations of the following method may be conducted upon approval of the Project Manager in accordance with the project-specific plan.

- Macrocore samplers fitted with detachable aluminum or steel drive points are driven into the ground using hydraulic pressure. If there is concrete or pavement over a sampling location, a Roto-hammer is used to drill a minimum 1.5-inch diameter hole through the surface material. A Roto-hammer may also be used if very dense soils are encountered.

- The sampler is advanced continuously in 4-foot intervals or less if desired. No soil cuttings are generated because the soil which is not collected in the sampler is displaced within the formation.

- The sampler is retracted from the hole, and the 4-foot continuous sample is removed from the outer coring tube. The sample is contained within an inner acetate liner.

- Attach the metal trough from the Geoprobe® Sampling Kit firmly to the tail gate of a vehicle. If a vehicle with a tail gate is not available, secure the trough on another suitable surface.

- Place the acetate liner containing the soils in the trough.

- While wearing cut-resistant gloves (constructed of leather or other suitable material), cut the acetate liner through its entire length using the double-bladed knife that accompanies the Geoprobe® Sampling Kit. Then remove the strip of acetate from the trough to gain access to the collected soils. Do not attempt to cut the acetate liner while holding it in your hand.

- Field screen the sample with an FID or PID, and observe/examine the sample (according to SOP GH-1.3). If appropriate, transfer the sample to sample bottles for laboratory analysis. If additional volume is required, push an additional boring adjacent to the first and composite/mix the same interval. Field compositing is usually not acceptable for sample requiring volatile organics analysis.

- Once sampling has been completed, the hole is backfilled with bentonite chips or bentonite cement grout, depending upon project requirements. Asphalt or concrete patch is used to cap holes through paved or concrete areas. All holes should be finished smooth to existing grade.

- In the event the direct push van/truck cannot be driven to a remote location or a sampling location with difficult accessibility, sampling probes may be advanced and sampled manually or with air/electric operated equipment (e.g., jack hammer).

- Sampling equipment is decontaminated prior to collecting the next sample.

6.0 GROUNDWATER SAMPLING PROCEDURES

6.1 General

The most common methodology for the investigation of groundwater is the installation and sampling of permanent monitoring wells. If only groundwater screening is required, the installation and sampling of temporary well points may be performed. The advantage of temporary well point installation using DPT is reduced cost due to no or minimal disposal of drilling cuttings and well construction materials, and shorter installation/times sampling.

Two disadvantages of DPT drilling for well point installation are:

- In aquifers with low yields, well points may have to be sampled without purging or development.
- If volume requirements are high, this method can be time consuming for low yield aquifers.

6.2 Sampling Equipment

Equipment needed for temporary well installation and sampling using DPT includes, but is not limited, to the following:

- 2-foot x 1-inch diameter mill-slotted (0.005 to 0.02-inch) well point
- Connecting rods
- Roto-hammer with 1.5-inch bit
- Mechanical jack
- 1/4-inch OD polyethylene tubing
- 3/8-inch OD polyethylene tubing
- Peristaltic pump
- Standard decontamination equipment and solutions

6.3 DPT Temporary Well Point Installation and Sampling Methodology

There are several methods for the installation and sampling of temporary well points using DPT. The most common methodology is discussed below. Variations of the following method may be conducted upon approval of the Project Manager in accordance with the project specific plan.

- A 2-foot x 1-inch diameter mill-slotted (0.005 to 0.02-inch) well point attached to connecting rods is driven into the ground to the desired depth using a rotary electric hammer or other direct push drill rig. If there is concrete or pavement over a sampling location, a Roto-hammer or electric coring machine is used to drill a hole through the surface material.

- The well point will be allowed to equilibrate for at least 15 minutes, after which a measurement of the static water level will be taken. The initial measurement of the water level will be used to assess the amount of water which is present in the well point and to determine the amount of silt and sand infiltration that may have occurred.

- The well point will be developed using a peristaltic pump and polyethylene tubing to remove silt and sand which may have entered the well point. The well point is developed by inserting polyethylene tubing to the bottom of the well point and lifting and lowering the tubing slightly while the pump is operating. The pump will be operated at a maximum rate of approximately 2 liters per minute. After removal of sediment from the bottom of the well point, the well point will be vigorously pumped at maximum capacity until discharge water is visibly clear and no further sediments are being generated. Measurements of pH, specific conductance, temperature, and turbidity shall be recorded every 5 to 10 minutes during the purging process. After two consistent readings of pH, specific conductance, temperature and turbidity ($\pm$10 percent), the well may be sampled.

- A sample will be collected using the peristaltic pump set at the same or reduced speed as during well development. Samples (with the exception of the samples to be analyzed for volatile organic compounds, VOCs) will be collected directly from the pump discharge. Sample containers for VOCs will be filled by (first shutting off the pump) crimping the discharge end of the sample tubing when filled, removing the inlet end of the sample tubing from the well, suspending the inlet tubing above the vial, and allowing water to fill each vial by gravity flow.

- Once the groundwater sample has been collected, the connecting rods and well point will be removed from the hole with the direct push rig hydraulics. The hole will be backfilled with bentonite chips or bentonite cement grout, depending upon project requirements. Asphalt or concrete patch will be used to cap holes through paved or concrete areas. All holes will be finished smooth to existing grade.

- In the event the direct push van/truck cannot be driven to a remote location or sampling location with difficult accessibility, sampling probes may be advanced and sampled manually or with air/electric-operated equipment (e.g., jack hammer).

- Decontaminate the equipment before moving to the next location.

7.0 RECORDS

A record of all field procedures, tests, and observations must be recorded in the field logbook, boring logs, and sample log sheets, as needed. Entries should include all pertinent data regarding the investigation. The use of sketches and field landmarks will help to supplement the investigation and evaluation.

ATTACHMENT 1
SAFE WORK PERMIT FOR DPT OPERATIONS

Permit No. ____________ Date: ________________ Time: From __________ to __________

SECTION I: General Job Scope

I. Work limited to the following (description, area, equipment used): **Monitoring well drilling and installation through direct push technology**

II. Required Monitoring Instruments: ______________________________

III. Field Crew: ______________________________

IV. On-site Inspection conducted ☐ Yes ☐ No Initials of Inspector __________ __________ TtNUS

SECTION II: General Safety Requirements (To be filled in by permit issuer)

V. Protective equipment required
Level D ☒ Level B ☐
Level C ☐ Level A ☐
Detailed on Reverse

Respiratory equipment required
Full face APR ☐ Escape Pack ☐
Half face APR ☐ SCBA ☐
SKA-PAC SAR ☐ Bottle Trailer ☐
Skid Rig ☐ None ☒

Level D Minimum Requirements: Sleeved shirt and long pants, safety footwear, and work gloves. Safety glasses, hard hats, and hearing protection will be worn when working near or sampling in the vicinity of the DPT rig.

Modifications/Exceptions.

VI. Chemicals of Concern | Action Level(s) | Response Measures

VII. Additional Safety Equipment/Procedures
Hard-hat ☒ Yes ☐ No
Safety Glasses ☒ Yes ☐ No
Chemical/splash goggles ☐ Yes ☒ No
Splash Shield ☐ Yes ☒ No
Splash suits/coveralls ☐ Yes ☐ No
Steel toe Work shoes or boots ☒ Yes ☐ No
Hearing Protection (Plugs/Muffs) ☒ Yes ☐ No
Safety belt/harness ☐ Yes ☒ No
Radio ☐ Yes ☒ No
Barricades ☒ Yes ☐ No
Gloves (Type - __________) ☐ Yes ☐ No
Work/warming regimen ☐ Yes ☐ No
Modifications/Exceptions: Reflective vests for high traffic areas.

VIII. Procedure review with permit acceptors

	Yes	NA
Safety shower/eyewash (Location & Use)	☐	☒
Daily tail gate meetings	☒	☐
Contractor tools/equipment/PPE inspected	☐	☐
Emergency alarms	☐	☐
Evacuation routes	☐	☐
Assembly points	☐	☐

IX. Site Preparation
Utility Clearances obtained for areas of subsurface investigation ☐ Yes ☐ No
Physical hazards removed or blockaded ☐ Yes ☐ No
Site control boundaries demarcated/signage ☐ Yes ☐ No

X. Equipment Preparation

	Yes	NA
Equipment drained/depressurized	☐	☒
Equipment purged/cleaned	☐	☒
Isolation checklist completed	☐	☒
Electrical lockout required/field switch tested	☐	☒
Blinds/misalignments/blocks & bleeds in place	☐	☒
Hazardous materials on walls/behind liners considered	☐	☒

XI. Additional Permits required (Hot work, confined space entry). ☐ Yes ☐ No
If yes, complete permit required or contact Health Sciences, Pittsburgh Office

XII. Special instructions, precautions: ______________________________

Permit Issued by: ____________________ Permit Accepted by: ____________________

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ATTACHMENTS

1.0 PURPOSE

The purpose of this document is to specify a consistent procedure for the quality assurance review of electronic and hard copy databases. This SOP outlines the requirements for establishment of a Database Record File, Quality Assurance review procedures, and documentation of the Quality Assurance Review Process.

2.0 SCOPE

The methods described in this Standard Operating Procedure (SOP) shall be used consistently for all projects managed by Tetra Tech NUS (TtNUS).

3.0 GLOSSARY

Chain-of-Custody Form - A Chain-of-Custody Form is a printed form that accompanies a sample or a group of samples from the time of sample collection to the laboratory. The Chain-of-Custody Form is retained with the samples during transfer of samples from one custodian to another. The Chain-of-Custody Form is a controlled document that becomes part of the permanent project file. Chain-of-Custody and field documentation requirements are addressed in SOP SA-6.1.

Electronic Database - A database provided on a compact laser disk (CD). Such electronic databases will generally be prepared using public domain software such as DBase, RBase, Oracle, Visual FoxPro, Microsoft Access, Paradox, etc.

Hardcopy Database - A printed copy of a database prepared using the software discussed under the definition of an electronic database.

Form I - A printed copy of the analytical results for each sample.

Sample Tracking Summary - A printed record of sample information including the date the samples were collected, the number of samples collected, the sample matrix, the laboratory to which the samples were shipped, the associated analytical requirements for the samples, the date the analytical data were received from the laboratory, and the date that validation of the sample data was completed.

4.0 RESPONSIBILITIES

Database Records Custodian - It shall be the responsibility of the Database Records Custodian to update and file the Sample Tracking Summaries for all active projects on a weekly basis. It shall be the responsibility of the Database Records Custodian to ensure that the most recent copies of the Sample Tracking Summaries are placed in the Database Records file. It shall be the responsibility of the Database Records Custodian to ensure that a copy of all validation deliverables is provided to the Project Manager (for placement in the project file). It shall be the responsibility of the Database Records Custodian to ensure that photocopies of all validation deliverables and historical data and reports (as applicable) are placed in the Database Records file.

Data Validation Coordinator - It shall be the responsibility of the Data Validation Coordinator (or designee) to ensure that the Sample Tracking Summaries are maintained by the Database Records Custodian. It shall be the responsibility of the Data Validation Coordinator (or designee) to ensure that photocopies of all data validation deliverables are placed in the applicable Database Records file by the Database Records Custodian.

Earth Sciences Department Manager - It shall be the responsibility of the Earth Sciences Department Manager (or equivalent) to ensure that all field personnel are familiar with the requirements of this Standard Operating Procedure (specifically Section 5.5).

FOL - It shall be the responsibility of the FOL (FOL) of each project to ensure that all field technicians or sampling personnel are thoroughly familiar with this SOP, specifically regarding provision of the Chain-of-Custody Forms to the Database Records Custodian. Other responsibilities of the FOL are described in Sections 5.4 and 5.5.

Management Information Systems (MIS) Manager - It shall be the responsibility of the MIS Manager to ensure that copies of original electronic deliverables (CDs) are placed in both the project files and the Database Records File. It shall be the responsibility of the MIS Manager (or designee) to verify the completeness of the database (presence of all samples) in both electronic and hardcopy form in the Database Records File. It shall be the responsibility of the MIS Manager to ensure that Quality Assurance Reviews are completed and are attested to by Quality Assurance Reviewers. It shall be the responsibility of the MIS Manager to ensure that records of the Quality Assurance review process are placed in the Database Records File. It shall be the responsibility of the MIS Manager to ensure that both electronic and hardcopy forms of the final database are placed in both the project and the Database Record File. It shall be the responsibility of the MIS Manager to ensure that data validation qualifiers are entered in the database.

Furthermore, it shall be the responsibility of the MIS Manager to participate in project planning at the request of the Project Manager, specifically with respect to the generation of level of effort and schedule estimates. To support the project planning effort, the MIS Manager shall provide a copy of the MIS Request From included as Attachment A to the project manager. It shall be the responsibility of the MIS Manager to generate level of effort and budget estimates at the time database support is requested if a budget does not exist at the time of the request. The MIS Request Form shall be provided to the Project Manager at the time of any such requests. It shall be the responsibility of the MIS Manager to notify the Project Manager of any anticipated level of effort overruns or schedule noncompliances as soon as such problems arise along with full justification for any deviations from the budget estimates (provided they were generated by the MIS Manager). It shall be the responsibility of the MIS Manager to document any changes to the scope of work dictated by the Project Manager, along with an estimate of the impact of the change on the level of effort and the schedule.

Program/Department Managers - It shall be the responsibility of the Department and/or Program Managers (or designees) to inform their respective department's Project Managers of the existence and requirements of this SOP.

Project Manager - It shall be the responsibility of each Project Manager to determine the applicability of this SOP based on: (1) program-specific requirements, and (2) project size and objectives. It shall be the responsibility of the Project Manager (or designee) to ensure that the FOL is familiar with the requirements regarding Chain-of-Custody Form provision to the Database Records Custodian. It shall be the responsibility of the Project Manager (or designee) to determine which, if any, historical data are relevant and to ensure that such data (including all relevant information such as originating entity, sample locations, sampling dates, etc.) are provided to the Database Records Custodian for inclusion in the Database Records File. It shall be the responsibility of the Project Manager to obtain project planning input regarding the level of effort and schedule from the MIS Manager. It shall be the responsibility of the Project Manager to complete the database checklist (Attachment A) to support the level of effort and schedule estimate and to facilitate database preparation and subroutine execution.

Risk Assessment Department Manager - It shall be the responsibility of the Risk Assessment Department Manager to monitor compliance with this Standard Operating Procedure, to modify this SOP as necessary, and to take corrective action if necessary. Monitoring of the process shall be completed on a quarterly basis.

Quality Assurance Reviewers - It shall be the responsibility of the Quality Assurance Reviewers to verify the completeness of the sample results via review of the Chain-of-Custody Forms and Sample Tracking Summaries. It shall be the responsibility of the Quality Assurance Reviewers to ensure the correctness of the database via direct comparison of the hardcopy printout of the database and the hardcopy summaries of the original analytical data (e.g., Form Is provided in data validation deliverables). Correctness includes the presence of all relevant sample information (all sample information fields), agreement of the laboratory and database analytical results, and the presence of data validation qualifiers.

Quality Manager - It shall be the responsibility of the Quality Manager to monitor compliance with this Standard Operating Procedure via routine audits.

5.0 PROCEDURES

5.1 Introduction

Verification of the accuracy and completeness of an electronic database can only be accomplished via comparison of a hardcopy of the database with hardcopy of all relevant sample information. The primary purposes of this SOP are to ensure that 1) all necessary hardcopy information is readily available to Quality Assurance Reviewers; 2) ensure that the Quality Assurance review is completed in a consistent and comprehensive manner, and; 3) ensure that documentation of the Quality Assurance review process is maintained in the project file.

5.2 File Establishment

A Database Record file shall be established for a specific project at the discretion of the Project Manager. Initiation of the filing procedure will commence upon receipt of the first set of Chain-of-Custody documents from a FOL or sampling technician. The Database Record Custodian shall establish a project-specific file for placement in the Database Record File. Each file in the Database Record File shall consist of standard components placed in the file as the project progresses. Each file shall be clearly labeled with the project number, which shall be placed on the front of the file drawer and on each and every hanging file folder relevant to the project. The following constitute the minimum components of a completed file:

- Electronic Deliverables
- Sample Tracking Forms
- Chain-of-Custody Forms
- Data Validation Letters
- Quality Assurance Records

5.3 Electronic Deliverables

The format of electronic deliverables shall be specified in the laboratory procurement specification and shall be provided by the laboratory. The integrity of all original electronic data deliverables shall be maintained. This shall be accomplished via the generation of copies of each electronic deliverable provided by the laboratory. The original electronic deliverable shall be provided to the project manager for inclusion in the project file. A copy of the original electronic deliverable shall be placed in the Database Record File. The second copy shall be maintained by the MIS Manager (or designee) to be used as a working copy.

5.4 Sample Tracking Forms

Updated versions of the sample tracking form for each relevant project shall be maintained by the Database Record Custodian. The Sample Tracking Forms shall be updated any time additional Chain-of-Custody Forms are received from a FOL or sampling technician, or at any time that data are received from a laboratory, or at any time that validation of a given data package (sample delivery group) is completed. The Data Validation Coordinator shall inform the Database Record Custodian of the receipt of any data packages from the laboratory and of completion of validation of a given data package to facilitate updating of the Sample Tracking Form. The Database Record Custodian shall place a revised copy of the Sample Tracking Form in the Database Record File anytime it has been updated. Copies of the updated Sample Tracking Form shall also be provided to the project manager to apprise the project manager of sample package receipt, completion of validation, etc.

5.5 Chain-of-Custody Forms

The Chain-of-Custody Forms for all sampling efforts will be used as the basis for (1) updating the Sample Tracking Form, and (2) confirming that all required samples and associated analyses have been completed. It shall be the responsibility of the FOL (or sample technician) to provide a photocopy of all Chain-of-Custody Forms to the Database Record Custodian immediately upon completion of a sampling effort. The Database Record Custodian shall then place the copies of the Chain-of-Custody Form(s) in the Database Record File. Upon receipt of a sample data package from an analytical laboratory, the Data Validation Coordinator shall provide a copy of the laboratory Chain-of-Custody Form to the Database Record Custodian. The Database Record Custodian shall use this copy to update the Sample Tracking Summary and shall place the copy of the laboratory-provided Chain-of-Custody Form in the Database Record File. The photocopy of the laboratory-provided Chain-of Custody Form shall be stapled to the previously filed field copy. Upon receipt of all analytical data, two copies of the Chain-of-Custody will therefore be in the file. Review of the Chain-of-Custody Forms will therefore be a simple mechanism to determine if all data have been received. Chain-of-Custody is addressed in SOP SA-6.1.

5.6 Data Validation Letters

All data validation deliverables (or raw data summaries if validation is not conducted) shall be provided for inclusion in both the Database Record File and the project file. If USEPA regional- or client-specific requirements are such that Form Is (or similar analytical results) need not be provided with the validation deliverable, copies of such results must be appended to the deliverable. It is preferable, although not essential that the validation qualifiers be hand-written directly on the data summary forms. The data validation deliverables (and attendant analytical summaries) will provide the basis for direct comparison of the database printout and the raw data and qualifiers.

5.7 Historical Data

At the direction of the Project Manager, historical data may also be included in a project-specific analytical database. In the event that historical data are germane to the project, hardcopy of the historical data must be included in the Database Record File. Historical data may be maintained in the form of final reports or as raw data. The information contained in the historical data file must be sufficient to identify its origin, its collection date, the sample location, the matrix, and any and all other pertinent information. All available analytical data, Chain-of-Custody Forms, boring logs, well construction logs, sample location maps, shall be photocopied by the Project Manager (or designee) and placed in one or more 3-ring binders. All information shall be organized chronologically by matrix. It shall be the responsibility of the Project Manager (or designee) to ensure that all inconsistencies between analytical data, Chain-of-Custody Forms, boring logs, sample log sheets, and field logbooks are identified and corrected. The Project Manager (or designee) shall decide which nomenclature is appropriate and edit, initial and date all relevant forms. Data entry may only be performed on information that has undergone the aforementioned editing process, thereby having a direct correlation between hardcopy information and what will become the electronic database.

6.0 RECORDS

Records regarding database preparation and quality assurance review include all those identified in the previous section. Upon completion of the database task, records from the file will be forwarded to the Project Manager for inclusion in the project file, or will be placed in bankers boxes (or equivalent) for storage. The final records for storage shall include the following minimum information on placards placed on both the top and end of the storage box:

Database Record File
PROJECT NUMBER: ____
SITE NAME: _________
DATE FILED: __/__/__
SUMMARY OF CONTENTS ENCLOSED
BOX _ OF _

Project- or program-specific record keeping requirements shall take precedence over the record keeping requirements of this SOP.

ATTACHMENT A

Tetra Tech NUS, Inc.

MIS REQUEST FORM

Project Name: ____ Request Date: ____
CTO: ____ Date Data Available for Production: ____
Project Manager: ____ Request in Support of: ____
Requestor: ____ Database Lead: ____
Program/Client: ____ GIS Lead: ____
State/EPA Region: ____ Statistics Lead: ____
Risk Lead: ____
Site Name(s) (Area, OU, etc.): ____
Sampling Date(s): ____
Matrix: ☐ GW ☐ SO ☐ SD ☐ SW ☐ Other: ____

Labels: ☐ Labels needed for an upcoming sampling event ____ Total # of Samples
____ Estimated Hours
____ Due Date
____ Complete ETS Charge No.
____ FOL
Additional Instructions: ____

Data Entry:
☐ Chemical data needs to be entered from hardcopy ____ Estimated # of Samples
☐ Chemical data needs to be formated electronically
☐ Field analytical data needs to be entered from hardcopy
☐ Geologic data needs to be entered from hardcopy
☐ Hydrology data needs to be entered from hardcopy
____ Estimated Hours
____ Due Date
____ Complete ETS Charge No.
Additional Instructions: ____

Tables:
☐ Full Data Printout
☐ Summary of Positive Hits
☐ Occurance and Distribution ☐ with criteria
☐ Sampling Analytical Summary
☐ Other: ____
____ Estimated Hours
____ Due Date
____ Complete ETS Charge No.
Additional Instructions: ____

GIS:
☐ General Facility Location
☐ Site Location
☐ Potentiometric Contours/Groundwater Flow
☐ Sample Location Proposed
☐ Sample Location Existing
☐ Tag Map Single Round
☐ Tag Map Multiple Round
☐ Isoconcentrations
☐ Chart Map
☐ 3D Visualization
☐ EGIS CD
☐ Other: ____
____ Estimated Hours
____ Due Date
____ Complete ETS Charge No.
Additional Instructions: ____

Statistics: ☐ Yes
____ Estimated Hours
____ Due Date
____ Complete ETS Charge No.
Additional Instructions: ____

Geostatistics: ☐ Yes
____ Estimated Hours
____ Due Date
____ Complete ETS Charge No.
Additional Instructions: ____

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1.0 INORGANICS (CLP STATEMENT OF WORK (SOW) ILM04.0)

Inductively Coupled Plasma Emission Spectroscopy (ICP) - Analytes commonly analyzed using ICP include: aluminum, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, nickel, potassium, silver, sodium, vanadium, and zinc.

Graphite Furnace Atomic Absorption Spectroscopy (GFAA) - Analytes commonly analyzed using GFAA include: antimony, arsenic, lead, selenium, and thallium

Cold Vapor Methodology - Mercury is commonly analyzed using cold vapor methodology.

Automated Colorimetric Technique - Cyanide is commonly analyzed using automated colorimetric methodology.

1.1 Applicability

This method is applicable to a large number of matrices including EP extracts, TCLP extracts, industrial wastes, soils, groundwater, aqueous samples, sludges, sediments, and other solid wastes. All matrices require digestion prior to analysis.

1.2 Data Overview Prior to Validation Process

1.2.1 Data Completeness

The data reviewer must initially verify that all CLP Forms are present and complete (i.e., Forms 1 through 14 must be provided). Areas of special attention when accounting for required CLP Forms will include:

- Verify at least one Initial and Continuing Calibration Verification (ICV/CCV) Percent Recovery (%R) calculation as noted on the Form 2A.

- When reviewing Form 2B, verify that all atomic absorption (GFAA) analytes are present in the CRDL standard at concentrations at the CRDL. Verify that all ICP analytes (with the exceptions of Al, Ba, Ca, Fe, Mg, Na and K) are present in the CRDL standard at concentrations of 2X CRDL.

- Verify that a matrix-specific laboratory generated preparation blank has been analyzed for each respective matrix as noted on the Form 3 (note that filtered and unfiltered aqueous matrices are to be treated as distinctly different matrices).

- Verify that all ICP analytes are present in both ICSA and ICSAB solutions. (Note that 3/90 SOW ILM03.0 does not require that antimony, sodium, and potassium be present in these solutions). Also verify from the raw data that the laboratory reported all analytes present in solution A to the nearest whole number. It is not uncommon for laboratories to incorrectly report "zeros" or simply leave blank the appropriate solution A columns. Furthermore, %Rs for solution AB are to be reported to one decimal place on the Form 4.

- Check that one matrix spike was analyzed for each particular matrix per analytical batch. Laboratories typically will not include an aqueous matrix for waters if the only aqueous samples contained in the SDG are field quality control blanks (i.e., equipment rinsate blanks and/or field blanks). This is generally accepted without data validation letter text comment. Additionally, the data reviewer may want to verify spiking levels as noted on pg. E-20 of ILM04.0 Inorganic SOW.

- Verify that laboratory duplicate analyses were performed for each matrix. **NOTE**: Field quality control blanks are never to be designated for quality control analyses.

- Check that one Laboratory Control Sample (LCS) was analyzed for each batch of samples per matrix within an SDG. **NOTE**: An aqueous LCS is not required for mercury and cyanide analysis.

- The Method of Standard Additions (MSA) Form 8 may or may not be present as dictated by Post Digestion Spike (PDS) %Rs. See Section 3.1.3.11 for further details.

- Verify that at least one ICP serial dilution analysis was performed for each matrix within an SDG. **NOTE**: Typically one serial dilution will serve to monitor a given set of samples within an SDG. However, special contractual requirements may necessitate one serial dilution analysis per sample. Ascertain atypical serial dilution frequency requirements through the project manager.

- Simply check that the Form 11 ICP Interelement Correction Factors (Annually) is present.

- Verify that all ICP analytical results fall within the ICP Quarterly Linear Ranges provided on the Form 12. Verify that no GFAA analytical results exceed the highest standard used in the associated GFAA calibration.

- Verify that the Form 13 Preparation Log accounts for aqueous/soil ICP, AA, mercury, and cyanide digestions/distillations as applicable.

- Examine the Form 14s to verify that one and only one "X" flag has been used to signify each reported field sample result or quality control sample result. Laboratories are often careless when entering the "X" flag. An incorrectly entered "X" flag can lead to reporting errors for the sample and its associated QC. The validator must verify reported results in instances of discrepancies, amend appropriate forms, and mention in letter text.

Actions - Notify the appropriate laboratory contact of required resubmittals when discrepancies are noted on the forms discussed above.

1.3 <u>Technical Evaluation Summary</u>

All data evaluations must be conducted in accordance with current and applicable USEPA Regional protocols and/or specific client contractual requirements and obligations. The applicable documents must be referenced to during the data evaluation process as this Standard Operating Procedure (S.O.P) is intended as proprietary in-house guidance for general inorganic validation practices only.

General parameters such as Data Completeness, Overall System Performance, and Detection Limits must be evaluated concurrently with the parameters discussed below.

1.3.1 Holding Times

Holding times are calculated from date of sample collection to date of sample analysis. The date of sample collection must be obtained from the Chain-of-Custody (COC) form. The date of sample analysis is best retrieved from the raw data but may also be obtained from the Form 14.

Sample preservation and holding time requirements are as follows:

- Metals - 6 months; pH <2
- Mercury - 28 days; pH <2
- Cyanide - 14 days; pH >12

Preservation requirements as noted above are applicable to aqueous samples only; solid samples do not receive preservative, but require maintenance at 4 C (2 C) during shipment and storage.

Actions - Holding time exceedances result in potentially low-biased results; thus, positive results and nondetects shall be qualified as estimated, (J) and (UJ), respectively. **NOTE**: Gross holding time noncompliances are defined as holding times which are exceeded by a factor or 2X. In these extreme cases, it is practice to reject (R) nondetects while positive results are qualified based upon professional judgment regarding the reliability of the associated data.

1.3.2 Initial Calibration Requirements

Calibration must be initiated daily and prior to sample analysis. The following calibration standard requirements must be verified:

- **ICP analyses** - must employ a blank and at least one standard.
- **GFAA analyses** - must employ a blank and at least three standards. One of the standards must be at the CRDL. Additionally, the calibration correlation coefficient (r) must be checked for linearity for each GFAA analysis performed (i.e., r = 0.995 or greater).
- **Mercury analyses** - must employ a blank and at least four standards (r = 0.995 or greater).
- **Cyanide analyses** - must employ a blank and at least three standards (r = 0.995 or greater). **NOTE:** The midpoint standard for cyanide analyses must be distilled; verify this via distillation logs.

1.3.3 Initial and Continuing Calibration Verification (ICV/CCV)

Review Initial and Continuing Calibration Verification Form 2As and associated raw data. The ICV/CCV %R quality control limits are 90-110% for metals, 80-120% for mercury, and 85-115% for cyanide.

Actions - If ICV/CCV %Rs are low, qualify as estimated (J) positive results and (UJ) nondetects. If ICV/CCV %Rs are high, qualify as estimated (J) positive results; nondetects are not affected. Gross exceedance, as defined by applicable data validation protocol, may require rejection (R) of results. **NOTE:** Qualify results of only those samples associated with the noncompliant ICB or CCV (generally, those samples immediately preceding or following the noncompliant standard until the nearest in-control standard).

1.3.4 CRDL Standard Analysis

Review CRDL Standard Form 2Bs and associated new data. The CRDL Standard analysis %R quality control limits are 80-120% for all metals.

Actions - If CRDL %Rs are low, qualify as estimated (J) positive results <3X CRDL and (UJ) nondetects. Generally, if CRDL %Rs are high, qualify as estimated (J) positive results <3X CRDL; nondetects remain unaffected. Note that when using EPA Region I validation guidelines, nondetects will receive qualification based upon high CRDL Standard analysis recovery. **NOTE:** The data reviewer need not specify affected samples; common practice is to apply data qualifications "across-the-board" based upon LOE time constraints.

1.3.5 Laboratory Method and Field Quality Control Blanks

Verify that a preparation blank was analyzed for each matrix and for each batch of 20 samples or each sample batch digested, whichever is more frequent. Continuing Calibration Blanks (CCBs) must be run at a frequency of 10% or every 2 hours whichever is more frequent.

The data reviewer will select the maximum contaminant level for each analyte in a particular matrix from which shall be calculated an "action level." The action level shall be established as 5X the maximum contaminant level but must be adjusted for dilution factor, moisture content, and sample weight prior to application.

ICB/CCB contamination shall be applied to all samples within an SDG. Preparation blank contamination shall be applied to samples of the same matrix only. Common practice shall be to qualify as nondetected (U) any contaminant present in sample which is considered a laboratory artifact (i.e., < the established action level). Professional judgment must be employed when discerning the validity of a concentration present in a field quality control blank. In many instances, contamination present in these blanks can be attributable to "dirty" laboratory practice and not actual field contaminant conditions.

Negative concentrations detected in the laboratory method blanks are indicative of instrumental problems and base-line drifting. Generally, any negative concentration > IDL shall warrant estimation [(J) positives and (UJ) nondetects] of the associated sample data regardless of matrix. Action levels shall not be established for negative concentration levels.

Actions - Qualify as nondetected (U) any positive result within the action level. Qualify as estimated (J) positive results and (UJ) nondetects for analytes for which negative concentrations were noted in the laboratory method blanks (i.e., ICBs, CCBs, and/or preparation blanks).

1.3.6 ICP Interference Check Sample (ICS) Results

Review ICP Interference Check Sample Form 4 and associated raw data. Verify that all recoveries for the ICP ICS solution fall within the 80-120% quality control window established for the ICS AB solution.
Actions - For ICS %Rs <80%, qualify as estimated (J) positive results and (UJ) nondetects in affected samples. For ICS %Rs >120%, qualify as estimated (J) positive results in affected samples; nondetects are unaffected by high ICS solution AB recovery. **NOTE:** Affected samples include all samples analyzed between the initial and final solutions (or within the eight hour working shift, whichever occurs more frequently) which contain Al, Ca, Fe, or Mg at levels >50% of the respective concentration of Al, Ca, Fe, or Mg in the ICS True Solution A.

Next, review concentrations of the four common interfering analytes (aluminum, calcium, iron, and magnesium) in the environmental samples. Any aforementioned interferant present in the environmental samples at concentrations which exceed 50% of those present in the ICS solution for that same analyte will require calculation of estimated elemental interference stemming from high interfering analyte concentration. If the previous condition is met; review the ICP/ICS Form 4 and note any analytes present in the ICS solution A at levels which exceed the IDL and which are not present in the ICS True solution A. Positive results in the ICS solution A indicate potentially elevated results for this analyte in the affected sample while negative results in the ICS solution A indicate potentially suppressed results for this analyte in the affected sample.

Next, an estimated elemental interference must be calculated for each analyte > IDL present in the ICS solution A which is not present in the ICS True solution A. The following equation shall be employed:

$$\text{Estimated elemental intf.} = \frac{[\text{Conc. affected analyte in ICS Soln A}] \times [\text{Interferent}]\,[\text{Conc. in Sample}]}{\text{Interferent Conc. in ICS Soln A}}$$

It is advisable, although not necessary, to routinely choose the lowest concentration for the interferant level in the ICS so as to calculate the highest estimated interference possible. This method lends itself to a more conservative overall data quality review.

Estimated interferences for each affected analyte > IDL in the ICSA solution must now be compared to the reported environmental sample result for that particular analyte.

Actions - For estimated interferences <10% of the reported sample concentration for a particular affected analyte, take no action; interference is considered negligible. For estimated interferences >10% of the reported sample concentration for a particular affected analyte, qualify (J) positive result and/or (UJ) nondetect for affected analyte in affected sample. (**NOTE**: Calculation of an estimated positive (potentially elevated) interference will have no effect on a reported nondetect; thus, no action is necessary).

1.3.7 Matrix Spike Sample Analysis (Pre-digestion)

Review Spike Sample Recovery Form 5A and associated raw data. Verify that at least one matrix spike was performed for each matrix for a given set of samples within an SDG. **NOTE:** Filtered and unfiltered samples are to be treated as distinctly different sample matrices and qualified accordingly. Refer to ILM03.0, 3/90 Inorganic SOW, Table 3, "SPIKING LEVELS FOR SPIKING SAMPLE ANALYSIS," page 20, Section E, for proper analyte spiking concentrations and requirements. Any deviations from the SOW shall be noted and require laboratory contact for correction.

Aqueous and soil Matrix Spike (MS) recoveries must be within the 75-125% quality control window in instances where the initial sample result is <4X amount spiked. If the initial sample result is >4X the amount spiked and the MS %R is noncompliant; no actions shall be taken.

Actions - For MS %Rs <30%, qualify as estimated (J) positive results and reject (R) nondetects in affected samples. For MS %Rs <75% but >30%, qualify as estimated (J) positive results and (UJ) nondetects in affected samples. For MS %Rs >125%, qualify as estimated (J) positive results in affected samples; nondetects are not compromised by high MS recovery; thus, no actions are warranted.

1.3.8 Laboratory Duplicate Precision

Review Duplicates Form 6 and associated raw data. Verify that one duplicate sample analysis was performed for each group of samples of a similar matrix within an SDG. Control criteria used to evaluate aqueous laboratory duplicates are as follows:

- a control limit of 20% for relative percent difference when sample and duplicate results are >5X CRDL
- a control limit of 1X CRDL for the difference between the sample values when sample and/or duplicate results are <5X CRDL

Control criteria used to evaluate solid laboratory duplicates are as follows:

- a control limit of 35% for relative percent difference when sample and duplicate results are >5X CRDL
- a control limit of 2X CRDL for the difference between the sample values when sample and/or duplicate results are <5X CRDL

NOTE: Review the CLP Form 6 carefully and verify that the laboratory has in fact reported a %RPD of 200% and not simply recorded the %RPD as noncalculable (in instances where the sample result is positive but the duplicate result is nondetect). Overlooking this minor point may result in incomplete sample data qualification in some instances.

Actions - For any situation involving laboratory duplicate imprecision, qualify as estimated (J) positive results and (UJ) nondetects in affected samples. **NOTE:** It is important to note in the letter text the cause of laboratory duplicate imprecision (i.e., noncompliant %RPD or noncompliant difference between sample and duplicate results).

1.3.9 Field Duplicate Precision

Field duplicates can be determined via Project Manager informational documents (i.e., sampling logs) or obtained from Chain-of-Custody (COC) forms. Field duplicates are generally identified as samples having identical sample collection times and dates. In instances were field duplicate samples are included with the sample data set, the following control criteria are generally used to evaluate aqueous field duplicates:

- a control limit of 30% for relative percent difference when sample and duplicate results are >5X CRDL
- a control limit of 2X CRDL for the difference between the sample values when sample and/or duplicate results are <5X CRDL

Similarly, the following control criteria are generally used to evaluate solid field duplicates:

- a control limit of 50% for the relative percent difference when sample and duplicate results are >5X CRDL
- a control limit of 4X CRDL for the difference between the sample values when sample and/or duplicate results are <5X CRDL

NOTE: The %RPD should reflect a difference of 200% and should not simply be recorded as noncalculable in instances where the sample result is positive but the field duplicate result is nondetect. Overlooking this minor point may result in incomplete sample data qualification in some instances.

Actions - For any situation involving field duplicate imprecision, qualify as estimated (J) positive results and (UJ) nondetects in affected samples. **NOTE:** It is important to note in the letter text the cause of field duplicate imprecision (i.e., noncompliant %RPD or noncompliant difference between sample and duplicate results). Furthermore, laboratory duplicate data qualifications, as per Brown & Root Environmental convention, shall be matrix-specific but otherwise "across-the-board" for TAL inorganic analyses. However, field duplicate data validation qualifications shall be limited to the field duplicate pair only.

1.3.10 Laboratory Control Sample (LCS) Results

Review Laboratory Control Sample Form 7 and associated raw data. Verify that an LCS was analyzed for each matrix and for each batch of twenty samples or batch of samples digested (whichever is more frequent) within an SDG. The quality control criteria established for evaluation of aqueous LCS analyses are 80-120%. NOTE: An aqueous LCS is not required for mercury and cyanide analysis, and silver and antimony are not subject to quality control criteria. Verify that all solid "found values" fall within the EPA established control limits for soils.

Actions - Aqueous LCS: In instances where aqueous LCS %R <80%, qualify as estimated (J) positive results and (UJ) nondetects. If aqueous LCS %R >120, qualify as estimated (J) positive results. Solid

LCS: In instances where solid found value is below lower quality control limit, qualify as estimated (J) positive results and (UJ) nondetects. If solid LCS found value exceeds EPA upper limit for soils, qualify as estimated (J) positive results.

1.3.11 Method of Standard Additions (MSA)

Review MSA Form 8 and verify instrument linearity by checking that all calibration correlation coefficients (r) are greater than or equal to 0.995. MSAs for a particular analyte in a particular sample may be run more than once. Check reanalyses in instances where initial MSA analysis yields (r) <0.995. It is good practice to review one or two GFAA post-digestion spike (PDS) %Rs via reviewing unspiked and spiked sample concentrations and associated PDS recovery to verify that the Furnace Atomic Absorption Analysis Scheme has been followed as per directional guidance noted on page E-28, document ILM03.0. Actions - If calibration correlation coefficient (r) <0.995, qualify as estimated (J) positive result and/ or (UJ) nondetect in affected sample. NOTE: The "Q" column on the Form 1 of the affected sample should contain an "S" flag for that particular analyte to indicate that the result was obtained using MSA. A "+" flag should also be recorded when the MSA correlation coefficient (r) <0.995. Review the appropriate Form I and amend if necessary.

1.3.12 ICP Serial Dilution Analysis

Review ICP Serial Dilutions Form 9 and associated raw data. Verify that a serial dilution was performed for each matrix and that all ICP analytes are included on the Form 9 with corresponding recovery calculations. Check the calculated Percent Difference (%D) column in instances where the diluted sample result is nondetected. In this situation, the laboratory should report a %D of 100% and not simply list the %D as noncalculable. Overlooking this minor point may result in incomplete sample data qualification in some instances. Amend the Form 9 if necessary. All %Ds for ICP serial dilution analyses should be <10% when concentrations of corresponding analytes in the original (undiluted) sample are minimally a factor of 50X IDL.

Actions - If %D >10% for an analyte, and the corresponding sample concentration is >50x IDL, qualify as estimated (J) positive results for that analyte in all samples of the same matrix. NOTE: The possibility of negative interference exists when the ICP serial dilution %D >10% and the diluted sample result is significantly > original (undiluted) sample result. Qualify as estimated (J) positive results and (UJ) nondetects in such instances.

1.3.13 EPA Analysis Run Logs Form 14s

The Form 14 serves several useful functions. It can be used to obtain sample analysis dates as noted in the heading of the page. Secondly, it is used to record any dilutions as applicable to ICP, GFAA, mercury, and cyanide analyses. And finally, it can be used to verify that GFAA PDS percent recoveries are within the 85-115% quality control limits. Additionally, the data reviewer should be careful to note that one and only one "X" flag has been used to indicate each reported field sample result or quality control sample result; this can be an area of frequent laboratory error.

Actions - If the PDS %R is <85%, qualify as estimated (J) the corresponding positive result and/or (UJ) nondetect in affected sample. If the PDS %R is >115%, qualify as estimated (J) the corresponding positive result in the affected sample; nondetects are not qualified based on high PDS %R.

1.3.14 Further GFAA Evaluations

It is necessary to review the raw data for GFAA analyses and verify that all Coefficients of Variation or Relative Standard Deviations (%RSDs) are <20% for reported sample results which exceed the CRDL.

Actions - If the CV or %RSD exceeds 20% and the reported sample result is > CRDL, qualify as estimated (J) positive result in affected sample.

1.4 Deliverables Guidance

In addition to any specific USEPA Regional requirements (e.g. data validation memorandum, data summary spreadsheets, USEPA Regional worksheets), all laboratory data package quality control summary forms, sample Form I reports, method blank Form Is, and the Chain-of-Custody report must be given to the Data Validation Quality Assurance Officer (DV/QAO) for quality assurance review.

The validator should ensure that the format of the data validation deliverable is complete and correct (in accordance with the appropriate USEPA Regional or client requirements) and that the validation narrative is free of transcription and typographical errors before submitting all requested items for DV/QAO review.

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		Effective Date 08/13/01	Revision 0
		Applicability Tetra Tech NUS, Inc.	
		Prepared Risk Assessment Department	
Subject DATA VALIDATION - CLP ORGANICS FOR SOLID AND AQUEOUS MATRICES		Approved D. Senovich	

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1.0 CLP ORGANICS BY GC/MS

1.1 Volatiles (USEPA CLP Statement of Work (SOW) OLM04.2/OLC02.1)

1.1.1 Applicability

CLP 3/90 volatile methodology is used to determine organic compounds in most matrices including groundwater, sludges, caustic liquors, acid liquors, waste solvents, oily wastes, mousses, tars, fibrous wastes, polymeric emulsions, filter cakes, spent carbons, spent catalysts, soils, and sediments.

The CLP volatile Target Compound List (TCL) includes the following compounds:

Acetone	1,4-Dichlorobenzene	Methyl acetate
Benzene	1,2-Dibromo-3-chloro-propane	Methylcyclohexane
Bromodichloromethane	Dibromochloromethane	Methylene Chloride
Bromoform	Dichlorodifluoromethane	4-Methyl-2-Pentanone
Bromomethane	1,2-Dibromoethane	MTBE
2-Butanone	1,1-Dichloroethane	Styrene
Carbon Disulfide	1,2-Dichloroethane	1,1,2,2-Tetrachloroethane
Carbon Tetrachloride	1,1-Dichloroethene	Tetrachloroethene
Chlorobenzene	1,2-Dichloroethene (total)	Toluene
Chloroethane	1,2-Dichloropropane	1,1,2-Trichloro-1,2,2-Trifluoroethane
Chloroform	cis-1,3-Dichloropropene	1,2,4-Trichlorobenzene
Chloromethane	trans-1,3-Dichloropropene	1,1,1-Trichloroethane
Cyclohexane	Ethyl Benzene	1,1,2-Trichloroethane
1,2-Dichlorobenzene	2-Hexanone	Trichloroethene
1,3-Dichlorobenzene	Isopropylbenzene	Vinyl Chloride
		Xylenes (total)

This method is based upon a purge-and-trap, gas chromatographic/mass spectrometric (GC/MS) procedure. Prior to analysis, samples must be prepared according to the SOW.

1.1.2 Interferences

Samples can be contaminated by diffusion of volatile organics (particularly chlorofluorocarbons and methylene chloride) through the sample container septum during shipment and storage. Associated field quality control blanks are analyzed in order to monitor this.

Contamination by carryover can occur whenever high-level and low-level samples are sequentially analyzed. To reduce carryover, the sample syringe or purging device is rinsed with reagent water between samples. Whenever an unusually concentrated sample is encountered, it should be followed by an analysis of reagent water to check for cross contamination.

If sample or matrix interferences are encountered, a secondary or alternate analytical column may be used to resolve the compounds of interest.

1.1.3 General Laboratory Practices

A method blank consisting of organic free water spiked with surrogates and internal standards should be analyzed immediately following each daily calibration, and also after the analysis of every high concentration sample.

Matrix Spike/Matrix Spike Duplicate (MS/MSD) analyses should be conducted to determine the effects of sample matrix upon the compounds of interest.

1.1.4 Sample Preparation

A purge- and -trap procedure is performed to prepare and extract volatile compounds from samples and to introduce those compounds into the GC/MS.

For highly volatile matrices, direct injection preceded by dilution should be used to prevent gross contamination of the instrumentation. For pastes, dilution of the sample until it becomes free-flowing is used to ensure adequate interfacial area. The success of this method depends on the level of interferences in the sample; results may vary due to the large variability and complicated matrices of solid waste samples.

1.1.5 Data Overview Prior to Validation

Before commencing validation, the reviewer must preview the associated Chain-of-Custody (COC) reports to determine:

- If the appropriate number of samples are present in the data package and if each sample was correctly analyzed for the parameters and methods specified.

- The identity of all associated field quality control blanks and field duplicate pairs.

Because many samples may have required dilutions, re-extractions and/or re-analyses, the validator should preview the data package contents to determine which analyses represent the better quality data.

Unless specifically directed by client protocol, never annotate the laboratory data package. Before beginning evaluation, prepare working copies (i.e., photocopies) of all Form I reports (including those for samples, laboratory method blanks and MS/MSD analyses), and all laboratory quality control summary forms (including all initial and continuing calibration summary statistics).

1.1.6 Technical Evaluation Summary

All data evaluations must be conducted in accordance with applicable USEPA Regional protocols and/or specific client contract requirements. The applicable documents must be referenced during the data evaluation process as this S.O.P. is only intended as a general procedure for the data validation tasks.

General parameters such as Data Completeness, Overall System Performance, Chromatographic Quality, Detection Limits and Compound Identification are evaluated concurrently with the parameters discussed in the following subsections.

1.1.6.1 Holding Times

Holding times are evaluated by reviewing the COC reports, the individual sample Form I reports, and the associated laboratory raw data. Holding times are calculated from date of collection to date of analysis.

For unpreserved aqueous samples, generally a 7-day maximum holding time allowance for aromatic compounds, along with a 14-day maximum holding time allowance for chlorinated hydrocarbons is used.

The technical maximum holding time allowance for aqueous samples preserved with hydrochloric acid (HCl) is 14 days.

No technical holding times have been for solid matrices promulgated; a 14-day maximum holding time allowance is currently being used.

Positive results in affected samples are generally qualified as estimated (J); nondetects (UJ). These results are biased low. Some USEPA Regions apply the bias qualifiers, L and UL, instead. If the holding times are exceeded by a factor of 2 or more, the holding time exceedance is considered to be gross, and positive results are generally qualified as estimated (J); nondetects are generally considered to be unreliable and are qualified (R). Results for which the holding time was grossly exceeded are biased very low.

1.1.6.2 Calibration

Check that an initial calibration was performed for each instrument used for analysis and that all calibrations were performed at all appropriate concentration levels within 12 hours of the associated instrument tuning.

Review the data package Form Vs (tuning) using the applicable USEPA Regional Functional Guidelines, and qualify the data as appropriate.

Review initial calibration Form VIs and the associated laboratory raw data. Determine which compounds have average Relative Response Factors (RRFs) <0.050 and which compounds have Percent Relative Standard Deviations (%RSDs) >50 and between 30%-50%. Circle these noncompliances on your working copies of these Forms. Spot-check (i.e., recalculate) a few of the RRFs and %RSDs to verify the laboratory's computation.

Determine which samples are affected by reviewing the continuing calibration Form VIIs. Check the initial calibration date(s) noted in the headings of the Form VIIs to determine which continuing calibrations are associated with which initial calibrations. Next, review the sample listings given on the data package Form Vs. Match the indicated continuing calibration run with the appropriate Form VII by matching the laboratory file ID numbers. Write the affected samples (those listed on the matched Form V) on your working copies of the appropriate Form VI and VII.

Review the continuing calibration Form VIIs and the associated laboratory raw data. Determine which compounds have RRFs <0.050 and which compounds have Percent Differences (%Ds) >50, and between 25%-50%; circle the noncompliances on your working copies of these Forms. Spot-check (i.e., recalculate) a few of the RRFs and %Ds to verify the laboratory's computation.

Generally, affected positive results for compounds for which RRFs are <0.050 are qualified as estimated (J); nondetects are rejected (R). In accordance with some USEPA Regional protocol, the (L) qualifier may be used instead of (J) when qualifying positive results. Bias for these results is very low.

Generally, positive results for compounds for which %RSD exceeds 50% or %D exceeds 25% are qualified as estimated (J); nondetects (UJ). Check the specific applicable data validation protocol for further guidance as there are some protocols which reject nondetects if the %RSD or %D is excessive. Bias for these results cannot be determined.

Generally, positive results for compounds for which %RSD is between 30%-50% are qualified as estimated, (J). Qualification of nondetects is protocol-specific. Follow the rules given in the appropriate validation protocol.

1.1.6.3 Blank Contamination

When using the information given below and in the appropriate USEPA Regional Functional Guidelines, keep in mind that the validation action levels derived are sample specific and must be adjusted for dilution, sample aliquot used for analysis, and sample moisture content (when applicable).

The rules for qualifying data based on the occurrence of blank contamination vary based on regional protocols. The guidelines provided in the appropriate protocol should be followed.

Generally the blank contamination review process is completed by first considering the maximum amount of a particular contaminant occurring in the laboratory method blanks. (Do not consider lab blanks run after high concentration samples for purposes of determining carryover as laboratory method blanks!) Then repeat the process for contaminants occurring in the associated field quality control blanks. Action levels for qualification (10X or 5X depending upon whether or not the contaminant is a common contaminant) are then set. The list of common contaminants may vary among protocols. Additionally, some hierarchy among the field quality control blanks apply, and the manner in which the qualifiers are applied vary [i.e. use of (U) or (B); replacement by CRQL, etc.]. Refer to appropriate protocol for specific guidance.

1.1.6.4 Surrogates

Surrogates are evaluated by reviewing the laboratory data package Form II reports and the laboratory raw data. The quality control ranges are given on the laboratory data package Form IIs; circle any noncompliances on your working copies of these Forms.

Results for all compounds in an affected sample are qualified if any one of the surrogate spike compounds fail to meet the quality control criteria provided. Generally, for samples having a surrogate recovery <10%, positive results are qualified as estimated (J), nondetects are rejected (R). These results are biased low. For samples having a surrogate recovery which is low but >10%, positive results are generally qualified as estimated (J); nondetects (UJ). The bias qualifiers (L, UL) may be used instead, depending upon the specific USEPA Regional guidance. For samples having a surrogate recovery which is high, positive results are generally qualified as estimated (J, K) based on regional guidance; nondetects are not qualified based on high surrogate recoveries.

1.1.6.5 Matrix Spike/Matrix Spike Duplicate (MS/MSD)

Generally, no data are qualified based upon MS/MSD results alone. If qualification does occur, generally only the result for that particular noncompliant compound is qualified in the original unspiked sample. Refer to the applicable data validation protocol for specific procedures for appropriately evaluating MS/MSD analyses.

1.1.6.6 Internal Standards

Internal standards are evaluated by reviewing the data package Form VIIIs and the laboratory raw data. The quality control ranges are given on the Form VIIIs. Circle any noncompliances on your working copies of these forms; evaluate and qualify as stipulated in the appropriate data validation protocol.

1.1.6.7 Tentatively Identified Compounds (TICs)

TICs are evaluated using the laboratory data package Form I VOA-TIC reports and the laboratory raw data. The guidance given in the March 1990 National Functional Guidelines for USEPA Region III is very concise; use the information in this document to evaluate and qualify accordingly.

1.1.6.8 Other Considerations

Laboratory precision can be evaluated by comparing the unspiked sample results with MS/MSD analyses results for unspiked compounds. Consider nondetects and results reported at concentrations less than the Contract Required Quantitation Limit (CRQL) to be in agreement. Use professional judgment in determining whether to qualify sample results based on the comparison.

Likewise, compare the positive compound results for field duplicate samples. Generally, the Relative Percent Difference (RPD) between field duplicate results for the aqueous matrix should be <35%; for soil matrix results, <50%. Qualification of the sample data is limited to the specific field duplicate pair. Positive results for compounds showing imprecision are qualified as estimated (J); nondetects (UJ). Bias for these results cannot be determined.

In some USEPA Regions, a "Percent Solids" rule applies. For example, if a sediment sample contains <50% solids in USEPA Region II, all associated data are considered to be estimated and are qualified accordingly. Follow the appropriate protocol guidance when applicable.

1.1.6.9 Quantitation

Verify and record the quantitation of at least one compound per analytical fraction. If no positive results are reported, use the MS/MSD data to confirm proper computation by the laboratory. Validator and laboratory quantitations must agree within 10 percent.

1.1.7 Deliverables Guidance

In addition to any specific USEPA Regional requirements (e.g. data validation memorandum, data summary spreadsheets, Regional worksheets), all laboratory data package quality control summary forms, sample Form I reports, method blank Form Is, and the Chain-of-Custody report must be given to the Data Validation Quality Assurance Officer (DV/QAO) for quality assurance review.

The validator should ensure that the format of the data validation deliverable is complete and correct (in accordance with the appropriate USEPA Regional or client requirements) and that the validation narrative is free of transcription and typographical errors before submitting all requested items for DV/QAO review.

1.2 Semivolatiles (USEPA CLP Statement of Work (SOW) ILM04.2/OLC02.1)

1.2.1 Applicability

CLP semivolatile methodology is applicable to nearly all types of samples, regardless of water content, including groundwater, aqueous sludges, caustic liquors, acid liquors, waste solvents, oily wastes, mousses, tars, fibrous wastes, polymeric emulsions, filter cakes, spent carbons, spent catalysts, soils, and sediments. Method 8250 can be used to analyze groundwater samples as well.

The semivolatile TCL includes the following compounds:

Acenaphthene	2,2'-oxybis(1-Chloropropane)	Hexachlorocyclopentadiene
Acenaphthylene	Chrysene	Hexachloroethane
Acetophenone	Dibenzo(a,h)anthracene	Indeno(1,2,3-cd)pyrene
Anthracene	Dibenzofuran	Isophorone
Atrazine	1,2-Dichlorobenzene	2-Methylnaphthalene
Benzaldehyde	1,3-Dichlorobenzene	2-Methylphenol
Benzo(a)anthracene	1,4-Dichlorobenzene	4-Methylphenol
Benzo(b)fluoranthene	3,3'-Dichlorobenzidine	Naphthalene
Benzo(k)fluoranthene	2,4-Dichlorophenol	2-Nitroaniline
Benzo(g,h,i)perylene	Diethylphthalate	3-Nitroaniline
Benzo(a)pyrene	2,4-Dimethylphenol	4-Nitroaniline
1,1'-Biphenyl	Dimethylphthalate	Nitrobenzene
4-Bromophenyl-phenylether	Di-n-butylphthalate	2-Nitrophenol
Butylbenzylphthalate	4,6-Dinitro-2-methylphenol	4-Nitrophenol
Caprolactum	2,4-Dinitrophenol	N-Nitroso-di-n-propylamine
Carbazole	2,4-Dinitrotoluene	N-Nitroso-diphenylamine
4-Chloroaniline	2,6-Dinitrotoluene	Pentachlorophenol
bis(2-Chloroethoxy)methane	Di-n-octylphthalate	Phenanthrene
bis(2-Chloroethyl)ether	bis(2-Ethylhexyl)phthalate	Phenol
4-Chloro-3-methylphenol	Fluoranthene	Pyrene
2-Chloronaphthalene	Fluorene	1,2,4-Trichlorobenzene
2-Chlorophenol	Hexachlorobenzene	2,4,5-Trichlorophenol
4-Chlorophenyl-phenylether	Hexachlorobutadiene	2,4,6-Trichlorophenol

The preceding method is based upon solvent extractions followed by gas chromatographic/mass spectrometric (GC/MS) procedures.

1.2.2 Interferences

Solvents, reagents, glassware, and other sample processing hardware may yield discrete artifacts and/or elevated baselines causing misinterpretation of chromatograms. All these materials must be demonstrated to be free from interferences under the conditions of the analysis by running method blanks. The use of high purity reagents and solvents helps to minimize interference problems; purification of solvents by distillation in all-glass systems may be required.

Interferences co-extracted from the samples will vary considerably from source to source depending upon the diversity of the industrial complex or waste being sampled.

1.2.3 General Laboratory Practices

An extraction blank should be prepared with each batch of samples extracted.

Matrix Spike/Matrix Spike Duplicate (MS/MSD) analyses should be conducted to determine the effects of sample matrix upon the compounds of interest.

1.2.4 Sample Preparation

Prior to GC/MS analysis, aqueous samples are acidified to pH 2 and extracted with methylene chloride using a continuous liquid-liquid extractor. Both neat and diluted organic liquids may be analyzed by direct injection. Solid samples are extracted with 1:1 methylene chloride/acetone using a sonication procedure. Cleanup by Gel Permeation Chromatography (GPC) is required for solid sample extracts.

1.2.5 Data Overview to Validation

Before commencing validation, the reviewer must preview the associated Chain-of-Custody (COC) reports to determine:

- If the appropriate number of samples are present in the data package and if each sample was correctly analyzed for the parameters and methods specified.

- The identity of all associated field quality control blanks and field duplicate pairs.

Because many samples may have required dilutions, re-extraction and/or reanalyses, the data validator should preview the data package contents to determine which analyses represent the better quality data.

The data package should never be annotated unless specifically directed by client protocol. All Form I reports (including those for samples, laboratory method blanks, and MS/MSD analyses) and all laboratory quality control summary forms (including all initial and continuing calibration summary statistics) should be photocopied for use as working copies.

1.2.6 Technical Evaluation Summary

All data evaluations must be conducted in accordance with the appropriate USEPA Regional protocols (when applicable) and/or specified client contract requirements. The applicable documents must be referenced during the data validation process as this S.O.P. is only intended as a general procedure for all data validation tasks.

General parameters such as Data Completeness, Overall System Performance, Chromatographic Quality, Detection Limits and Compound Identification are evaluated concurrently with the parameters discussed in the following subsections.

1.2.6.1 Holding Times

Holding times are evaluated by reviewing the COC reports, the individual sample Form I reports, and the associated laboratory raw data. Holding times for extraction are calculated from date of collection to date of extraction.

The technical holding times for aqueous and solid matrices are as follows:

- Extraction: 7 days
- Analysis: 40 days from date of extraction

Affected positive results are generally qualified as estimated (J), nondetects (UJ). Alternately, the L or UL bias qualifiers may be used dependent upon the applicable USEPA Regional Guidance. If the sample was extracted beyond 14 days from collection, the holding time exceedance is considered to be gross and positive results are qualified as estimated (J) or (L); nondetects are rejected (R). Generally, if the holding time until extraction is exceeded, the affected sample results are considered to be biased low. If the holding time until analysis is exceeded (and potentially, some of the extract may have evaporated), the affected sample results may be considered to be biased high. Follow the qualification guidance given in the appropriate data validation protocol.

1.2.6.2 Calibration

Check that an initial calibration was performed for each instrument used for analysis and that all calibrations were performed at all appropriate concentration levels within 12 hours of the associated instrument tuning.

Review the data package Form Vs (tuning) using the applicable USEPA Regional Functional Guidelines, and qualify the data as appropriate.

Review initial calibration Form VIs and the associated laboratory raw data. Determine which compounds have average Relative Response Factors (RRFs) <0.050 and which compounds have Percent Relative Standard Deviations (%RSDs) >50 and between 30%-50%. Circle these noncompliances on your working copies of these Forms. Spot-check (i.e., recalculate) a few of the RRFs and %RSDs to verify the laboratory's computation.

Determine which samples are affected by reviewing the continuing calibration Form VIIs. Check the initial calibration date(s) noted in the headings of the Form VIIs to determine which continuing calibrations are associated with which initial calibrations. Next, review the sample listings given on the data package Form Vs. Match the indicated continuing calibration run with the appropriate Form VII by matching the laboratory file ID numbers. Write the affected samples (those listed on the matched Form V) on your working copies of the appropriate Form VI and VII.

Review the continuing calibration Form VIIs and the associated laboratory raw data. Determine which compounds have RRFs <0.050 and which compounds have Percent Differences (%Ds) >50, and between 25%-50%; circle the noncompliances on your working copies of these Forms. Spot-check (i.e., recalculate) a few of the RRFs and %Ds to verify the laboratory's computation.

Generally, affected positive results for compounds for which RRFs are <0.050 are qualified as estimated (J); nondetects are rejected (R). In accordance with some USEPA Regional protocol, the (L) qualifier may be used instead of (J) when qualifying positive results. Bias for these results is low.

Generally, positive results for compounds for which %RSD or %D exceeds 50% are qualified as estimated (J); nondetects (UJ). Check the specific applicable data validation protocol for further guidance as there are some protocol which reject nondetects if the %RSD or %D is excessive. Bias for these results cannot be determined.

Generally, positive results for compounds for which %RSD is between 30%-50% or %D is between 25%-50% are qualified as estimated (J). Qualification of nondetects is protocol-specific. Follow the rules given in the appropriate validation protocol.

1.2.6.3 Blank Contamination

Note that unlike VOA fraction analyses, a laboratory method blank does not have to be analyzed after every continuing calibration standard. Be very sure, however, that one semivolatile method blank was extracted for each day that associated samples were extracted (with a maximum of 20 samples per batch).

The action levels for qualification are 10X the maximum amount of phthalates found in the blanks (phthalates are common contaminants) and 5X the maximum amount of other contaminants found in the blanks. The actual action level applied is sample-specific and must be adjusted for dilution, sample aliquot used for analysis, and moisture content. The type and manner in which the qualifiers are applied vary with protocol [i.e., use of (U) or (B); replacement by CRQL, etc.]. Refer to appropriate data validation protocol for specific guidance.

1.2.6.4 Surrogates

Surrogates are evaluated by reviewing the laboratory data package Form II reports and the associated laboratory raw data. The quality control ranges are given on the laboratory data package Form IIs; circle any noncompliances on your working copies of these Forms.

Semivolatile compounds are divided into two classes, base-neutral compounds and acid-extractable compounds. Each class of compounds has its own associated surrogates. If the recovery is <10% for any one surrogate, positive results for all compounds in that class in the affected sample are qualified as estimated, (J) or (L), and nondetects are rejected, (R). These results are biased low.

No qualification actions are taken for samples having any one surrogate recovery which is noncompliant but >10%.

If the recoveries for any two surrogates of the same class are noncompliant but above 10%, all sample results for that class of compounds in the affected sample are qualified. If the recoveries are low, positive results are generally qualified as estimated (J); nondetects (UJ). In some Regions, the bias qualifiers, L and UL, may be used instead. If the recoveries for any two surrogates of the same class are high, positive results for all compounds in that class in the affected sample are qualified, J or K, depending upon the appropriate USEPA Regional guidance; nondetects are not qualified based on high surrogate recoveries.

1.2.6.5 Matrix Spike/Matrix Spike Duplicates

Generally, no data are qualified based upon MS/MSD results alone. If qualification does occur, generally only the result for that particular noncompliant compound is qualified in the original unspiked sample. Refer to the appropriate validation guidelines for specific procedures for evaluating MS/MSD analyses.

1.2.6.6 Internal Standards

Internal standards are evaluated by reviewing the data package Form VIIIs and the laboratory raw data. The quality control ranges are given on the Form VIIIs. Circle any noncompliances on your working copies of these forms; evaluate and qualify as stipulated in the appropriate protocol.

1.2.6.7 Tentatively Identified Compounds (TICs)

TICs are evaluated using the laboratory data package Form I BNA-TIC reports, and the laboratory raw data. The guidance given in the 3/90 National Functional Guidelines for USEPA Region III is very concise; evaluate and qualify accordingly.

1.2.6.8 Other Considerations

Laboratory precision can be evaluated by comparing MS/MSD sample results for unspiked compounds with the unspiked sample results. Consider nondetects and results reported at concentration levels less than the Contract Required Quantitation Limit (CRQL) to be in agreement. Use professional judgment in determining whether to qualify sample results based on the comparison.

Likewise, compare the positive compound results for field duplicate samples. Generally the Relative Percent Difference (RPD) between field duplicate results for the aqueous matrix should be less than 35%; for soil matrix results, less than 50%. Qualification of sample data is limited to that specific field duplicate pair. Positive results for compounds showing imprecision are qualified as estimated (J); and nondetects (UJ). Bias for these results cannot be determined.

In some USEPA regions a "Percent Solids" rule applies. For example, if a sediment contains less than 50% solids in USEPA Region II, all associated data are considered to be estimated and are qualified accordingly. Follow the appropriate protocol guidance when applicable.

1.2.6.9 Quantitation

Verify and record quantitation of at least one compound per analytical fraction. If no positive results are reported, use the MS/MSD data to confirm proper computation by the laboratory. Validator and laboratory quantitations must agree within 10 percent.

1.2.7 Deliverables Guidance

In addition to any specific USEPA Regional requirements (e.g., data validation memorandum, data summary spreadsheets, USEPA Regional worksheets), all laboratory data package quality control summary forms, sample Form I reports, method blank Form Is, and the Chain-of-Custody report must be given to the Data Validation Quality Assurance Officer (DV/QAO) for quality assurance review.

The validator should ensure that the format of the data validation deliverable is complete and correct (in accordance with the appropriate USEPA Regional or client requirements) and that the validation narrative is free of transcription and typographical errors before submitting all requested items for DV/QAO review.

2.0 CLP ORGANICS BY GC

2.1 Organochlorine Pesticides and Polychlorinated Biphenyls (PCBs) (USEPA CLP Statement of Work (SOW) OLM04.2/OLC02.1)

2.1.1 Applicability

CLP methodology is used to determine the concentration of certain organochlorine pesticides and polychlorinated biphenyls (PCBs) in groundwater, liquid, and solid sample matrices. Specifically, the CLP TCL includes the following substances:

Aldrin	Dieldrin	Methoxychlor
alpha-BHC	Endosulfan I	Toxaphene
beta-BHC	Endosulfan II	Aroclor-1016
delta-BHC	Endosulfan sulfate	Aroclor-1221
gamma-BHC (Lindane)	Endrin	Aroclor-1232
Chlordane	Endrin aldehyde	Aroclor-1242
4,4'-DDD	Endrin ketone	Aroclor-1248
4,4'-DDE	Heptachlor	Aroclor-1254
4,4'-DDT	Heptachlor epoxide	Aroclor-1260

CLP methodology for organochlorine pesticides and PCBs is a Gas Chromatographic (GC) procedure in which samples are first extracted and then analyzed by direct injection. The compounds of interest are analyzed via GC/ECD (Electron Capture Detector; an equivalent Halogen-Specific Detector may also be used).

2.1.2 Interferences

The sensitivity of these methods usually depends on the level of interferences rather than on instrumental limitations. Solvents, reagents, glassware, and other sample processing hardware may yield discrete artifacts and/or elevated baselines causing misinterpretation of gas chromatograms. The use of high purity reagents and solvents helps to minimize these interference problems. Extraction blanks are analyzed as method blanks in order to monitor the occurrences of interferences.

Interferences co-extracted from the sample will vary considerably and will dictate the nature and extent of clean-up procedures used. Phthalate esters are a common interference to organochlorine pesticide analyses; phenols and organic acids may act as interferents when analyzing for chlorinated herbicides.

2.1.3 General Laboratory Practices

An extraction blank should be prepared with each batch of samples extracted.

Matrix Spike/Matrix Spike Duplicate (MS/MSD) analyses should be conducted to determine the effects of sample matrix upon the compounds of interest.

Standard quality assurance practices such as the analyses of field replicates should also be employed.

2.1.4 Sample Preparation

Prior to GC analysis, aqueous samples are extracted at a neutral pH with methylene chloride as a solvent using a separatory funnel or a continuous liquid-liquid extractor. Solid samples are extracted with hexane:acetone (1:1) using sonication procedures.

2.1.5 Data Overview Prior to Validation

Before commencing validation, the reviewer must preview the associated Chain-of-Custody (COC) reports to determine:

- If the appropriate number of samples are present in the data package and if each sample was correctly analyzed for the parameters and methods specified.

- The identity of all associated field quality control blanks and field duplicate pairs.

Because many samples may have required dilutions, re-extractions and/or re-analyses, the validator should preview the data package contents to determine which analyses represent the better quality data.

Unless specifically directed by client protocol, never annotate the laboratory data package. Before beginning evaluation, prepare working copies (i.e., photocopies) of all Form I reports (including those for samples, laboratory method blanks and MS/MSD analyses) and all laboratory quality control summary forms.

2.1.6 Technical Evaluation Summary

All data evaluations must be conducted in accordance with applicable USEPA Regional protocols (when applicable) and/or specific client contract requirements. The applicable documents must be referenced during the data evaluation process as this S.O.P. is only intended as a general procedure for the data validation tasks.

General parameters such as Data Completeness, Overall System Performance, Chromatographic Quality, Detection Limits, and Compound Identification are evaluated concurrently with the parameters discussed in the following subsections.

2.1.6.1 Holding Times

Holding times are evaluated by reviewing the COC reports, the individual sample Form I reports, and the associated laboratory raw data. Holding times are calculated from date of collection to date of extraction/analysis.

All samples to be analyzed for pesticides, PCBs and/or herbicides must be extracted within 7 days of collection regardless of matrix and analyzed within 40 days of extraction.

When the holding time criteria are not met, positive results in affected samples are generally qualified as estimated (J); nondetects (UJ). These results are biased low. Some USEPA Regions apply the bias qualifiers, L and UL, instead. If the holding times are exceeded by a factor of 2 or more, the holding time exceedance is considered to be gross, and positive results are generally qualified as estimated (J); nondetects are generally considered to be unreliable and are rejected (R). These results are biased low.

2.1.6.2 Calibration

Data pertaining to the initial calibration (i.e., evaluation check for linearity) is found on the data package Form VIs. Check that the initial calibration was performed for each instrument used and at all appropriate concentration levels.

Generally, positive results for compounds whose Percent Relative Standard Deviation (%RSD) exceeds 20% are qualified as estimated (J). Check the pesticide analytical sequence (Form VIII) to determine which samples are affected. Check the specific applicable data validation protocol for further guidance as there are some protocol which reject nondetects if the %RSD or %D is excessive. Bias for these results cannot be determined. Follow the rules given in the appropriate data validation protocol.

Verify that a resolution check mixture, Performance Evaluation Mixture (PEM), Individual Standard Mixtures A and B, and multicomponent target compounds were analyzed at the proper frequency (see Form VIII) on each GC analytical column. Retention times for PEM target compounds and Individual Standard Mixtures A and B target compounds should be within the established retention time windows. If a compound is outside of the retention time window, further evaluation of the sample chromatograms is necessary. In addition, check that the Relative Percent Difference (RPD) (recorded on Forms VII-D and VII-E) between the calculated amount and true amount for each pesticide is 25%. If this criterion is not met, positive results and nondetects for the affected compounds are qualified as estimated, (J) and (UJ), respectively.

The DDT/Endrin Breakdown for each PEM should not exceed 20% (recorded on Form VII-D). Generally, if % breakdown for DDT exceeds 20%, estimate (J) all positive results for DDT, DDE and DDD following the last in-control standard until the next acceptable PEM (see analytical sequence); acceptability of the next individual A/B mix may also be considered when qualifying data for DDT breakdown. If there are no positive results for DDT but there are positive results for DDD or DDE then reject (R) nondetects for DDT in associated samples. Generally, if Endrin % Breakdown exceeds 20%, estimate (J) positive results for Endrin, Endrin Aldehyde, and Endrin Ketone in all samples following the last in-control standard until the next acceptable PEM; acceptability of the next individual A/B mix may also be considered when qualifying data for Endrin breakdown. If there are positive results for Endrin Aldehyde or Endrin Ketone but none for Endrin, reject (R) nondetect Endrin results.

2.1.6.3 Blank Contamination

When using the information provided below and in the appropriate data validation guidelines, keep in mind that the validation action levels derived are sample-specific and must be adjusted for dilution, sample aliquot used for analysis, and sample moisture content (when applicable).

The rules for qualifying data based on the occurrence of blank contamination vary based on regional protocols. Guidelines provided in the appropriate data validation protocol should be followed.

An action level of 5X the maximum amount of contaminant found is used to evaluate the sample data. The manner in which the qualifiers are applied vary [i.e. use of (U) or (B); replacement by CRQL, etc.]. Refer to appropriate validation protocol for specific guidance.

2.1.6.4 Surrogates

Surrogates are evaluated by reviewing the laboratory data package Form II reports and the associated laboratory raw data. The advisory limits are given on the laboratory data package Form IIs; circle any recoveries outside these limits on your working copies of these Forms.

No qualifications are made for surrogates which show zero recoveries because they were "diluted out." Generally, positive results affected by low surrogate recovery are qualified as estimated (J), or the (L) bias qualifier is used when applicable; nondetects are qualified (UJ) or (UL), accordingly. If a positive sample result is affected by high surrogate recovery, the result is qualified as estimated (J) or the (K) bias qualifier is used when applicable; nondetects are not qualified based on high surrogate recovery. Because the surrogate recovery limits for this fraction are advisory, generally no results are rejected.

The decachlorobiphenyl (DCB) and tetrachloro-m-xylene (TCX) retention times found on data package Form VIII must be 0.10 for DCB and 0.05 for TCX. If DCB and TCX retention time criteria are not met, the raw data must be checked for misidentified GC peaks. The validator's professional judgment for qualifications should be used.

2.1.6.5 Matrix Spike/Matrix Spike Duplicates

Generally, no data are qualified based upon MS/MSD results alone. If qualification does occur, generally only the result for that particular noncompliant compound is qualified in the original unspiked sample. Refer to the appropriate data validation guidelines for the specific procedures for evaluating MS/MSD analyses.

2.1.6.6 Other Considerations

Laboratory precision can be evaluated by comparing the unspiked sample results with MS/MSD analyses results for unspiked compounds. Consider nondetect results and results reported at concentrations less than the Contract Required Quantitation Limit (CRQL) to be in agreement. Use professional judgment in determining whether to qualify sample results based on the comparison.

Likewise, compare the positive compound results for field duplicate samples. Generally, the Relative Percent Difference (RPD) between field duplicate results for the aqueous matrix should be <35%; for soil matrix results, <50%. Qualification of the sample data is limited to the specific field duplicate pair. Positive results for compounds showing imprecision are qualified as estimated (J); nondetects (UJ). Bias for these results cannot be determined.

In some USEPA Regions, a "Percent Solids" rule applies. For example, if a sediment sample contains <50% solids in USEPA Region II, all associated data are considered to be estimated, and are qualified accordingly. Follow the appropriate protocol guidance when applicable.

2.1.6.7 Quantitation

Verify and record the quantitation of at least one compound per analytical fraction. If no positive results are reported, use the MS/MSD data to confirm proper computation by the laboratory. Validator and laboratory quantitations must agree within 10%.

2.1.7 Deliverables Guidance

In addition to any specific USEPA Regional requirements (e.g., data validation memorandum, data summary spreadsheets, USEPA Regional worksheets), all laboratory data package quality control summary forms, sample Form I reports, method blank Form Is, and the Chain-of-Custody report must be given to the Data Validation Quality Assurance Officer (DV/QAO) for quality assurance review.

The validator should ensure that the format of the data validation deliverable is complete and correct (in accordance with the appropriate USEPA Regional or client requirements) and that the validation narrative is free of transcription and typographical errors before submitting all requested items for DV/QAO review.

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		Effective Date 08/13/01	Revision 0
		Applicability Tetra Tech NUS, Inc.	
		Prepared Risk Assessment Department	
Subject DATA VALIDATION - POLYCHLORINATED DIBENZODIOXINS AND POLYCHLORINATED DIBENZOFURANS FOR SOLID AND AQUEOUS MATRICES		Approved D. Senovich	

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1.0 CLP DFLM 1.1/SW-846 METHODS 8280/8290

1.1 Applicability

Methods 8280, 8290 and CLP SOW DFLM1.1 are applicable for the determination of the tetra-, penta-, hexa-, hepta-, and octachlorinated congeners of dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs) (by Gas Chromatography/Mass Spectrometry (GC/MS) via selective ion monitoring) in chemical wastes including fuel oils, sludges, fly ash, still bottoms, reactor residues, soil, and water. Methods 8280 and DFLM1.1 are low resolution GC/MS techniques while Method 8290 is a high resolution GC/MS technique.

1.2 Dioxin Data Package Deliverable Minimum Requirements

The following information must be present in data package prior to the validation effort:

- Appropriate Chain-of-Custody (COC) Form(s)
- Laboratory Case Narrative documenting any particular analytical anomalies encountered and sample description information (i.e., sample cross-reference identifications)
- Calibration Summaries
- Laboratory Control Sample and Duplicate forms
- Single Control Samples and Method Blank Results
- Matrix Spike/Matrix Spike Duplicates
- Retention Time Marker Solutions
- Internal and Recovery Standard Area Summaries

The appropriate laboratory liaison must be contacted immediately if any of the above items have been omitted from the data package.

1.3 Technical Data Evaluation

NOTE: Analysis of a fortified standard and blank may be submitted as evidence of compliant Performance Evaluation (PE) analyses as per region-specific requirements. The fortified standard will contain 2,3,7,8-TCDD at a known quantity while the fortified blank will contain 1,2,3,4-TCDD plus other known interferents. The recovery for 2,3,7,8-TCDD recognition must be within the EPA's 99% confidence interval.

1.4 Quality Control

1.4.1 Holding Times and Sample Preservation

All samples are to be extracted within 30 days of sample collection, and all subsequent analyses are to be conducted within 45 days from the date of collection. **NOTE**: Data qualification based upon holding time noncompliances is rare due to the minor effect of extended storage time on PCDD/PCDF quantitation resulting from the inherent persistence and known stability of these compounds. However, estimation of associated sample data based on holding time shall be subject to the professional judgment of the data validator.

Sample preservation shall be checked by referencing the appropriate Chain-of-Custody (COC) form(s) and verifying that all samples receiving PCDD/PCDF analysis were cooled to and stored at 4 C.

1.4.2 Initial Calibration Verification

Review the average Relative Response Factors (RRFs) for all dioxin congeners by recalculating approximately 10% of the reported RRFs while also verifying proper use of quantitation ions. The following ions are specified for selective ion monitoring for PCDDs and PCDFs:

Analyte		Quantitation Ion	Confirmation Ions
PCDDs	Tetra	322	320
	Penta	356	354; 358
	Hexa	390	388; 392
	Hepta	424	422; 426
	Octa	460	458
PCDFs	Tetra	306	304
	Penta	340	338; 342
	Hexa	374	372; 376
	Hepta	408	406; 410
	Octa	444	442

Internal Standards

Analyte	Quantitation Ion	Confirmation Ion
13C12-2,3,7,8-TCDD	334	332
13C12-1,2,3,6,7,8-H_xCDD	404	402
13C12-OCDD	472	470
13C12-2,3,7,8-TCDF	318	316
13C12-1,2,3,4,6,7,8-H_pCDF	420	422

Recovery Standards

Analyte	Quantitation Ion	Confirmation Ion
13C12-1,2,3,4-TCDD	334	332
13C12-1,2,3,7,8,9-H_xCDD	404	402

Next verify the acceptability of isotopic ratios as outlined in the following table:

Analyte		Selected Ions	Relative m/z
PCDDs	Tetra	320/322	0.65-0.89
	Penta	356/358	1.24-1.86
	Hexa	390/392	1.05-1.43
	Hepta	424/426	0.88-1.20
	Octa	458/460	0.76-1.02
PCDFs	Tetra	304/306	0.65-0.89
	Penta	340/342	1.24-1.86
	Hexa	374/376	1.05-1.43
	Hepta	408/410	0.88-1.20
	Octa	442/444	0.76-1.02

Internal Standards

Analyte	Selected Ions	Relative m/z
13C12-2,3,7,8-TCDD	332/334	0.65-0.89
13C12-1,2,3,6,7,8-H_xCDD	402/404	1.05-1.43
13C12-OCDD	470/472	0.76-1.02
13C12-2,3,7,8-TCDF	316/318	0.65-0.89
13C12-1,2,3,4,6,7,8-H_pCDF	420/422	0.88-1.20

Recovery Standards

Analyte	Selected Ions	Relative m/z
13C12-1,2,3,4-TCDD	332/334	0.65-0.89
13C12-1,2,3,7,8,9-H_xCDD	402/404	1.05-1.43

Typically, the data reviewer can expect to associate the following congeners with their associated internal standards as follows:

Internal Standard #1 (13C12-2,3,7,8-TCDD)	TCDD, PeCDD
Internal Standard #2 (13C12-1,2,3,6,7,8-HxCDD)	HxCDD, HpCDD
Internal Standard #3 (13C-OCDD)	OCDD, OCDF
Internal Standard #4 (13C12-TCDF)	TCDF, PeCDF
Internal Standard #5 (13C12-HpCDF)	HxCDF, HpCDF

Additionally, verify that the Relative Standard Deviation (%RSD) for all target compounds and internal standards is 15%.

Actions - Qualify as estimated, (J) positive results and (UJ) nondetects in affected samples if RSD is >15%.

Window Defining Mix

This is a retention time check which must be run prior to the continuing calibration. The composition of the window defining mix may or may not be known. Review the following criteria:

- Peak separation must be 25% valley criterion for TCDD isomers
- Peak separation must be the 50% valley criterion for HxCDD isomers
- Multiple ion detection mass chromatograms and reconstructed ion chromatograms should be present for the window defining mix

Actions - Professional judgment (weighted primarily upon chromatographic expertise) must be employed when assigning data qualifications.

1.4.3 Continuing Calibration Verification

Evaluation of the CCV involves evaluating the Daily Standard (which is a standard that contains the required target compounds plus internal standards), versus the initial standard.

Verify that a Continuing Calibration Verification (CCV) was analyzed prior to sample analysis and at the beginning of each subsequent 12-hour period. A CCV must also be analyzed at the end of the final analysis period.

The Signal-to-Noise ratio (S/N) for all internal standards must be >10:1. No quality control criteria exist to govern internal standard recovery; however, internal standard advisory recovery limits of 40-120% were established in earlier EPA validation protocol.

Verify that the internal standard area count in the sample is -50% to +100% of the internal standard area count in the associated daily standard.

Complete one Percent Recovery ($\%R_{is}$) calculation for an internal standard as outlined in **equation A** below:

Equation A: $$\%R_{is} = \frac{(A_{is})(Q_{rs})}{(A_{rs})(RRF_{is})(Q_{is})} \times 100$$

where:

A_{is}	=	area of the quantitation ion of the internal standard
A_{rs}	=	area of the quantitation ion of the recovery standard
Q_{is}	=	ng of internal standard
Q_{rs}	=	ng of recovery standard
RRF_{is}	=	Relative Response Factor for the internal standard as determined from the associated continuing calibration

An RRF shall be calculated for each congener in the CCV solution. A Percent Difference (%D) of 30% from the average RRF must be accomplished for the CCV. **NOTE**: Recalculate some (approximately 10%) of the continuing calibration RRFs for thoroughness.

Actions - Qualify associated sample data as estimated, i.e., (J) positive results and (UJ) nondetects in affected samples in instances where CCV %D >30%. Qualify as rejected (R) all associated sample data in instances where the internal standard S/N ratio <10:1.

1.4.4 Laboratory Method Blank Evaluations

Verify that a laboratory generated method blank was analyzed prior to sample analysis and for each matrix and extraction batch for all samples within an SDG. The laboratory method blanks should be free from contamination and/or interferences stemming from glassware involved in sample preparation and subsequent analytical procedures, associated reagents and solvents, etc. The following criteria shall be employed for evaluation of contaminant levels present in laboratory method blanks:

- The signal of any confirmed analyte present in a method blank must be <2% of the signal of the associated internal standard (based on peak height or peak area). Comparison of contaminants present in the blanks at levels below the calibration range (i.e., contaminants present at levels which constitute <2% of the respective internal standard) shall not require reanalyses as stipulated by the method.

- An action level of 5X the maximum contaminant level shall be used in instances of positive detections.

- The data reviewer should complete a detection limit verification calculation.

- Detection limits are sample-specific dependent upon the concentration of a given analyte to produce a signal with a peak height 2.5 X the background signal.

- The data reviewer shall consider all applicable sample weight, moisture content, and dilution factors prior to application of the aforementioned action level.

- The data reviewer shall recalculate at least one Detection Limit (DL) using **equation B** as follows:

$$\text{Equation B:} \qquad DL = \frac{(2.5)(H_x)(Q_{is})}{(A_{is})(RRF_A)(W)}$$

where:

A_{is}	=	area of the quantitation ion of the internal standard
Q_{is}	=	ng of internal standard
H_x	=	peak height of noise for the analyte's quantitation ion
RRF_{is}	=	Relative Response Factor for the analyte as determined from the associated continuing calibration
W	=	dry weight of the sample (g)

Actions - Effects on sample data and subsequent data qualifications shall be upon the professional judgment of the data reviewer, but the following general qualifying guidance shall be employed; Qualify as nondetected (U) any positive result less than the corresponding action level.

1.4.5 Duplicate Control Samples

The Duplicate Control Sample (DCS) is a well-characterized matrix which is spiked and analyzed at approximately 10% of the sample load in order to establish method-specific quality control limits. The DCS spike recovery quality control limits of 60-140% shall be employed. Additionally, the RPDs between control sample and duplicate shall be below 50%.

Actions - Qualify as estimated (J) positive results in affected samples when DCS spike recoveries are >140%. Qualify as estimated (J) positive results and (UJ) nondetects in affected samples when DCS spike recoveries are <60%. Qualify as estimated (J) positive results and (UJ) nondetects in affected samples when %RPD between control and duplicate sample exceeds 50%.

1.4.6 Matrix Spike/Matrix Spike Duplicate Review

Verify that a matrix spike has been analyzed for each matrix and batch of samples within an SDG.

Verify that the %RSD between matrix spike and duplicate injections is 50%. Additionally, the following recovery limits shall be employed for the respective congeners:

Congener	Recovery Limits
TCDD	50-150%
PCDD	50-150%
HxCDD	50-150%
HpCDD	50-150%
OCDD	50-150%
TCDF	50-150%
PeCDF	50-150%
HxCDF	50-150%
HpCDF	50-150%
OCDF	50-150%

Actions - Qualify as estimated (J) only positive results in affected samples when the recovery exceeds the upper quality control limit. Qualify as estimated, (J) positive results and (UJ) nondetects in affected samples when the recovery is below the lower quality control limit.

1.4.7 Chromatographic Performance and Evaluation

Verify that the recovery standard area counts are within -50% to +100% of the area counts in the respective daily check standard.

Examine chromatographic acceptability by checking the chromatographic base-line for fluctuation (i.e., raising or lowering), peak shape and resolution. Proper peak resolution between 13C-2,3,7,8-TCDD and 13C-1,2,3,4-TCDD (or 13C-2,3,7,8-TCDD and its closest eluting isomer), shall be attained at a threshold acceptability level of <25%.

Actions - Data qualification shall be based upon the professional judgment of the data reviewer.

1.4.8 Sample Quantitation

Confirm the quantitation of at least one Estimated Maximum Positive Concentration (EMPC). The laboratory will report an EMPC as opposed to a confirmed, definite positive hit in instances where the S/N 2.5 for both the quantitation ion and confirmation ion for a given target isomer/analyte. The following equation shall be used to verify at least one EMPC calculation:

$$\mathrm{EMPC} = \frac{(A_x)(Q_{is})}{(A_{is})(RRF_A)(W)}$$

where: A_x = area of the quantitation or confirmation ion, whichever is lower
Q_{is}, A_{is}, RRF_A, and W are defined in the previous equation.

The data reviewer will also confirm at least one positive detection using the following equation:

$$C_A = \frac{(A_A)(Q_{is})}{(A_{is})(RRF_A)(W)}$$

where: A_{is}, Q_{is}, RRF_A, and W are defined in previous equations
C_A = analyte concentration (ng/g or ug/kg)
A_A = analyte quantitation ion area

NOTE: EMPC values are estimates by definition. If these values are used for risk assessment, it must be understood that an EMPC value is "less certain" that positive results which are qualified (J), since the qualified results meet identification criteria while EMPCs do not.

1.5 <u>Deliverables</u>

In addition to any work-request requirements (e.g., data validation memorandum), all laboratory data package quality control summary forms, laboratory summaries of sample results and laboratory method blanks, and COCs must be provided to the Data Validation Quality Assurance Officer (DV/QAO) for quality assurance review.

The validator should ensure that the format of the data validation deliverable is complete and correct, and that the validation narrative is free of transcription and typographical errors before submitting all requested items for DV/QAO review.

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		Effective Date 03/00	Revision 1
		Applicability Tetra Tech NUS, Inc.	
		Prepared Health & Safety	
Subject UTILITY LOCATING AND EXCAVATION CLEARANCE		Approved D. Senovich	

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1.0 PURPOSE

Utilities such as electric service lines, natural or propane gas lines, water and sewage lines, telecommunications, and steam lines are very often in the immediate vicinity of work locations. Contact with underground or overhead utilities can have serious consequences including employee injury/fatality, property and equipment damage, substantial financial impacts, and loss of utility service to users.

The purpose of this procedure is to provide minimum requirements and technical guidelines regarding the appropriate procedures to be followed when performing subsurface and overhead utility locating services. It is the policy of Tetra Tech NUS, Inc. (TtNUS) to provide a safe and healthful work environment for the protection of our employees. The purpose of this Standard Operating Procedure (SOP) is to aid in achieving the objectives of the TtNUS Utility Locating and Clearance Policy. The TtNUS Utility Locating and Clearance Policy must be reviewed by anyone potentially involved with underground or overhead utility services.

2.0 SCOPE

This procedure applies to all TtNUS field activities where there may be potential contact with underground or overhead utilities. This procedure provides a description of the principles of operation, instrumentation, applicability, and implementability of typical methods used to determine the presence or absence of utility services. This procedure is intended to assist with work planning and scheduling, resource planning, field implementation, and subcontractor procurement. Utility locating and excavation clearance requires site-specific information prior to the development of detailed operating procedures. This guidance is not intended to provide a detailed description of methodology and instrument operation. Specialized expertise during both planning and execution of several of the geophysical methods may also be required.

3.0 GLOSSARY

<u>Electromagnetic Induction (EMI) Survey</u> - A geophysical exploration method whereby electromagnetic fields are induced in the ground and the resultant secondary electromagnetic fields are detected as a measure of ground conductivity.

<u>Magnetometer</u> – A device used for precise and sensitive measurements of magnetic fields.

<u>Magnetic Survey</u> – A geophysical survey method that depends on detection of magnetic anomalies caused by the presence of buried ferromagnetic objects.

<u>Metal Detection</u> – A geophysical survey method that is based on electromagnetic coupling caused by underground conductive objects.

<u>Vertical Gradiometer</u> – A magnetometer equipped with two sensors that are vertically separated by a fixed distance. It is best suited to map near surface features and is less susceptible to deep geologic features.

<u>Ground Penetrating Radar</u> – Ground Penetrating Radar (GPR) involves specialized radar equipment whereby a signal is sent into the ground via a transmitter. Some portion of the signal will be reflected from the subsurface material, which is then recorded with a receiver and electronically converted into a graphic picture.

4.0 RESPONSIBILITIES

<u>Project Manager (PM)/Task Order Manager (TOM)</u> - Responsible for ensuring that all field activities are conducted in accordance with this procedure and the TtNUS Utility Locating and Clearance Policy.

Site Manager (SM)/Field Operations Leader (FOL) - Responsible for the onsite verification that all field activities are performed in compliance with approved SOPs or as otherwise directed by the approved project plan(s).

Site Health & Safety Officer (SHSO) – Responsible to provide technical assistance and verify full compliance with this SOP and the TtNUS Utility Locating and Clearance Policy. The SHSO is also responsible for reporting any deficiencies to the Corporate Health and Safety Manager (HSM) and to the PM/TOM.

Health & Safety Manager (HSM) – Responsible for preparing, implementing, and modifying corporate health and safety policy.

Site Personnel – Responsible for understanding and implementing this SOP and the TtNUS Utility Locating and Clearance Policy.

5.0 PROCEDURES

This procedure addresses the requirements and technical procedures that must be performed to minimize the potential for contact with underground and overhead utility services. These procedures are addressed individually from a buried and overhead standpoint.

5.1 Buried Utilities

Buried utilities present a heightened concern because their location is not typically obvious by visual observation, and it is common that their presence and/or location is unknown or incorrectly known on client properties. The following procedure must be followed prior to beginning any excavation that might potentially be in the vicinity of underground utility services. In addition, the Utility Clearance Form (Attachment 3) must be completed for every location or cluster of locations where intrusive activities will occur.

Where the positive identification and de-energizing of underground utilities cannot be obtained and confirmed using the following steps, the PM/TOM is responsible for arranging for the procurement of a qualified, experienced, utility locating subcontractor who will accomplish the utility location and demarcation duties specified herein.

1. A comprehensive review must be made of any available property maps, blue lines, or as-builts prior to site activities. Interviews with local personnel familiar with the area should be performed to provide additional information concerning the location of potential underground utilities. Information regarding utility locations shall be added to project maps upon completion of this exercise.

2., A visual site inspection must be performed to compare the site plan information to actual field conditions. Any findings must be documented and the site plan/maps revised. The area(s) of proposed excavation or other subsurface activities must be marked at the site in white paint or pin flags to identify those locations of the proposed intrusive activities. The site inspection should focus on locating surface indications of potential underground utilities. Items of interest include the presence of nearby area lights, telephone service, drainage grates, fire hydrants, electrical service vaults/panels, asphalt/concrete scares and patches, and topographical depressions. Note the location of any emergency shut off switches. Any additional information regarding utility locations shall be added to project maps upon completion of this exercise and returned to the PM/TOM.

3. If the planned work is to be conducted on private property (e.g., military installations, manufacturing facilities, etc.) the FOL must identify and contact appropriate facility personnel (e.g., public works or facility engineering) before any intrusive work begins to inquire about (and comply with) property owner requirements. It is important to note that private property owners may require several days to several weeks advance notice prior to locating utilities.

4. If the work location is on public property, the state agency that performs utility clearances must be notified (see Attachment 1). State "one-call" services must be notified prior to commencing fieldwork per their requirements. Most one-call services require, by law, 48- to 72-hour advance notice prior to beginning any excavation. Such services typically assign a "ticket" number to the particular site. This ticket number must be recorded for future reference and is valid for a specific period of time, but may be extended by contacting the service again. The utility service will notify utility representatives who then mark their respective lines within the specified time frame. It should be noted that most military installations own their own utilities but may lease service and maintenance from area providers. Given this situation, "one call" systems may still be required to provide location services on military installations.

5. Utilities must be identified and their locations plainly marked using pin flags, spray paint, or other accepted means. The location of all utilities must be noted on a field sketch for future inclusion on project maps. Utility locations are to be identified using the following industry-standard color code scheme, unless the property owner or utility locator service uses a different color code:

white	excavation/subsurface investigation location
red	electrical
yellow	gas, oil, steam
orange	telephone, communications
blue	water, irrigation, slurry
green	sewer, drain

6. Where utility locations are not confirmed with a high degree of confidence through drawings, schematics, location services, etc., the work area must be thoroughly investigated prior to beginning the excavation. In these situations, utilities must be identified using such methods as passive and intrusive surveys, physical probing, or hand augering. Each method has advantages and disadvantages including complexity, applicability, and price. It also should be noted that in many states, initial excavation is required by hand to a specified depth.

7. At each location where trenching or excavating will occur using a backhoe or other heavy equipment, and where utility identifications and locations cannot be confirmed prior to groundbreaking, the soil must be probed with a hand auger or pole (tile probe) made of non-conductive material. If these efforts are not successful in clearing the excavation area of suspect utilities, hand shoveling must be performed for the perimeter of the intended excavation.

8. All utilities uncovered or undermined during excavation must be structurally supported to prevent potential damage. Unless necessary as an emergency corrective measure, TtNUS shall not make any repairs or modifications to existing utility lines without prior permission of the utility owner, property owner, and Corporate HSM. All repairs require that the line be locked-out/tagged-out prior to work.

5.2 Overhead Power Lines

If it is necessary to work within the minimum clearance distance of an overhead power line, the overhead line must be de-energized and grounded, or re-routed by the utility company or a registered electrician. If protective measures such as guarding, isolating, or insulating are provided, these precautions must be adequate to prevent employees from contacting such lines directly with any part of their body or indirectly though conductive materials, tools, or equipment.

The following table provides the required minimum clearances for working in proximity to overhead power lines.

Nominal Voltage	Minimum Clearance
0 -50 kV	10 feet, or one mast length; whichever is greater
50+ kV	10 feet plus 4 inches for every 10 kV over 50 kV or 1.5 mast lengths; whichever is greater

6.0 UNDERGROUND LOCATING TECHNIQUES

6.1 Geophysical Methods

Geophysical methods include electromagnetic induction, magnetics, and ground penetrating radar. Additional details concerning the design and implementation of electromagnetic induction, magnetics, and ground penetrating radar surveys can be found in one or more of the TtNUS SOPs included in the References (Section 8.0).

Electromagnetic Induction

Electromagnetic Induction (EMI) line locators operate either by locating a background signal or by locating a signal introduced into the utility line using a transmitter. A utility line acts like a radio antenna, producing electrons, which can be picked up with a radiofrequency receiver. Electrical current carrying conductors have a 60HZ signal associated with them. This signal occurs in all power lines regardless of voltage. Utilities in close proximity to power lines or used as grounds may also have a 60HZ signal, which can be picked up with an EM receiver. A typical example of this type of geophysical equipment is an EM-61.

EMI locators specifically designed for utility locating use a special signal that is either indirectly induced onto a utility line by placing the transmitter above the line or directly induced using an induction clamp. The clamp induces a signal on the specific utility and is the preferred method of tracing since there is little chance of the resulting signals being interfered with. A good example of this type of equipment is the Schonstedt® MAC-51B locator. The MAC-51B performs inductively traced surveys, simple magnetic locating, and traced nonmetallic surveys.

When access can be gained inside a conduit to be traced, a flexible insulated trace wire can be used. This is very useful for non-metallic conduits but is limited by the availability of gaining access inside the pipe.

Magnetics

Magnetic locators operate by detecting the relative amounts of buried ferrous metal. They are incapable of locating or identifying nonferrous utility lines but can be very useful for locating underground storage tanks (UST's), steel utility lines, and buried electrical lines. A typical example of this type of equipment is the Schonstedt® GA-52Cx locator. The GA-52Cx is capable of locating 4-inch steel pipe up to 8 feet deep.

Non-ferrous lines are often located by using a typical plumbing tool (snake) fed through the line. A signal is then introduced to the snake that is then traced.

Ground Penetrating Radar

Ground Penetrating Radar (GPR) involves specialized radar equipment whereby a signal is sent into the ground via a transmitter. Some portion of the signal will be reflected from the subsurface material, which is then recorded with a receiver and electronically converted into a graphic picture. In general, an object which is harder than the surrounding soil will reflect a stronger signal. Utilities, tunnels, UST's, and footings will reflect a stronger signal than the surrounding soil. Although this surface detection method may determine the location of a utility, this method does not specifically identify utilities (i.e., water vs. gas, electrical vs. telephone); hence, verification may be necessary using other methods. This method is somewhat limited when used in areas with clay soil types or with a high water table.

6.2 Passive Detection Surveys

Acoustic Surveys

Acoustic location methods are generally most applicable to waterlines or gas lines. A highly sensitive Acoustic Receiver listens for background sounds of water flowing (at joints, leaks, etc.) or to sounds introduced into the water main using a transducer. Acoustics may also be applicable to determine the location of plastic gas lines.

Thermal Imaging

Thermal (i.e., infrared) imaging is a passive method for detecting the heat emitted by an object. Electronics in the infrared camera convert subtle heat differentials into a visual image on the viewfinder or a monitor. The operator does not look for an exact temperature; rather they look for heat anomalies (either elevated or suppressed temperatures) characteristic of a potential utility line.

The thermal fingerprint of underground utilities results from differences in temperature between the atmosphere and the fluid present in a pipe or the heat generated by electrical resistance. In addition, infrared scanners may be capable of detecting differences in the compaction, temperature and moisture content of underground utility trenches. High-performance thermal imagery can detect temperature differences to hundredths of a degree.

6.3 Intrusive Detection Surveys

Vacuum Excavation

Vacuum excavation is used to physically expose utility services. The process involves removing the surface material over approximately a 1' x 1' area at the site location. The air-vacuum process proceeds with the simultaneous action of compressed air-jets to loosen soil and vacuum extraction of the resulting debris. This process ensures the integrity of the utility line during the excavation process, as no hammers, blades, or heavy mechanical equipment comes into contact with the utility line, eliminating the risk of damage to utilities. The process continues until the utility is uncovered. Vacuum excavation can be used at the proposed site location to excavate below the "utility window" which is usually 8 feet.

Hand-auger Surveys

When the identification and location of underground utilities cannot be positively confirmed through document reviews and/or other methods, borings must be hand-augered for all locations where there is a potential to impact buried utilities. The minimum hand-auger depth that must be reached is to be determined considering the geographical location of the work site. This approach recognizes that the placement of buried utilities is influenced by frost line depths that vary by geographical region. Attachment 2 presents frost line depths for the regions of the contiguous United States. At a minimum, hand-auger depths must be at least to the frost line depth plus two (2) feet, but never less than 4 feet below ground surface (bgs). For augering, the hole must be reamed by hand to at least the diameter of the drill rig auger or bit prior to drilling. For soil gas surveys, the survey probe shall be placed as close as possible to the cleared hand-auger. It is important to note that a post-hole digger must not be used in place of a hand-auger.

Tile Probe Surveys

For some soil types, site conditions, and excavation requirements, tile probes may be used instead of or in addition to hand-augers. Tile probes must be performed to the same depth requirements as hand-augers. Depending upon the site conditions and intended probe usage, tile probes should be made of non-conductive material such as fiberglass.

7.0 INTRUSIVE ACTIVITIES SUMMARY

The following list summarizes the activities that must be performed prior to beginning subsurface activities:

1. Map and mark all subsurface locations and excavation boundaries using white paint or markers specified by the client or property owner.

2. Notify the property owner and/or client that the locations are marked. At this point, drawings of locations or excavation boundaries shall be provided to the property owner and/or client so they may initiate (if applicable) utility clearance.

   Note: Drawings with confirmed locations should be provided to the property owner and/or client as soon as possible to reduce potential time delays.

3. Notify “One Call” service. If possible, arrange for an appointment to show the One Call representative the subsurface locations or excavation boundaries in person. This will provide a better location designation to the utilities they represent. You should have additional drawings should you need to provide plot plans to the One Call service.

4. Complete Attachment 3, Utility Clearance Form. This form should be completed for each excavation location. In situations where multiple subsurface locations exist within the close proximity of one another, one form may be used for multiple locations provided those locations are noted on the Utility Clearance Form. Upon completion, the Utility Clearance Form and revised/annotated utility location map becomes part of the project file.

8.0 REFERENCES

TtNUS Utility Locating and Clearance Policy
TtNUS SOP GH-3.1; Resistivity and Electromagnetic Induction
TtNUS SOP GH-3.2; Magnetic and Metal Detection Surveys
TtNUS SOP GH-3.4; Ground-penetrating Radar Surveys

ATTACHMENT 1
LISTING OF UNDERGROUND UTILITY CLEARANCE RESOURCES

ALABAMA
Alabama Line Location (800) 292-8525

Tucson Blue Stake Center (800) 782-5348

Alaska
Locate Call Center of Alaska Inc. (800) 478-3121

Arizona
Arizona Blue Stake Inc. (800) 782-5348

Arkansas
Arkansas One Call System Inc. (800) 482-8998

California
Underground Service Alert North (800) 227-2600

Underground Service Alert South (800) 227-2600

Colorado
Utility Notification Center of Colorado
(800) 922-1987

Connecticut
Call Before You Dig (800) 922-4455

Delaware
Miss Utility of Delmarva
(800) 282-8555

District of Columbia
Miss Utility (800) 257-7777

Florida
Call Sunshine (800) 432-4770

Georgia
Utilities Protection Center Inc.
(800) 282-7411

Idaho
Palouse Empire Underground Coordinating Council
(800) 882-1974

Utilities Underground Location Center
(800) 424-5555

Kootenai Country Utility Coordinating Council
(800) 428-4950

Shoshone County One Call (800) 398-3285

Dig Line (800) 342-1585

One Call Concepts (800) 626-4950

Illinois
Julie Inc. (800) 892-0123

Digger (Chicago Utility Alert Network)
(312) 744-7000

Indiana
Indiana Underground Plant Protection Services
(800) 382-5544

Iowa
Underground Plant Location Service Inc.
(800) 292-8989

Kansas
Kansas One-Call Center (800) 344-7233

Kentucky
Kentucky Underground Protection Inc.
(800) 752-6007

Louisiana
Louisiana One Call (800) 272-3020

Maine
Dig Safe – Maine (800) 225-4977

Maryland
Miss Utility (800) 257-777

Miss Utility of Delmarva (800) 282-8555

Massachusetts
Dig Safe – Massachusetts (800) 322-4844

Michigan
Miss Dig System (800) 482-7171

Minnesota
Gopher State One Call (800) 252-1166

Mississippi
Mississippi One-Call System Inc. (800) 227-6477

Missouri
Missouri One Call System Inc. (800) 344-7483

Montana
Utilities Underground Location Center
(800) 424-5555

Montana One Call Center (800) 551-8344

Nebraska
Diggers Hotline of Nebraska (800) 331-5666

Nevada
Underground Service Alert North (800) 227-2600

New Hampshire
Dig Safe – New Hampshire (800) 225-4977

New Jersey
New Jersey One Call (800) 272-1000

New Mexico
New Mexico One Call System Inc.
(800) 321-ALERT

Las Cruces-Dona Utility Council (505) 526-0400

New York
Underground Facilities Protection Organization
(800) 962-7962

New York City: Long Island One Call Center
(800) 272-4480

North Carolina
The North Carolina One-Call Center Inc.
(800) 632-4949

North Dakota
Utilities Underground Location Center
(800) 795-0555

Ohio
Ohio Utilities Protection Service
(800) 362-2764

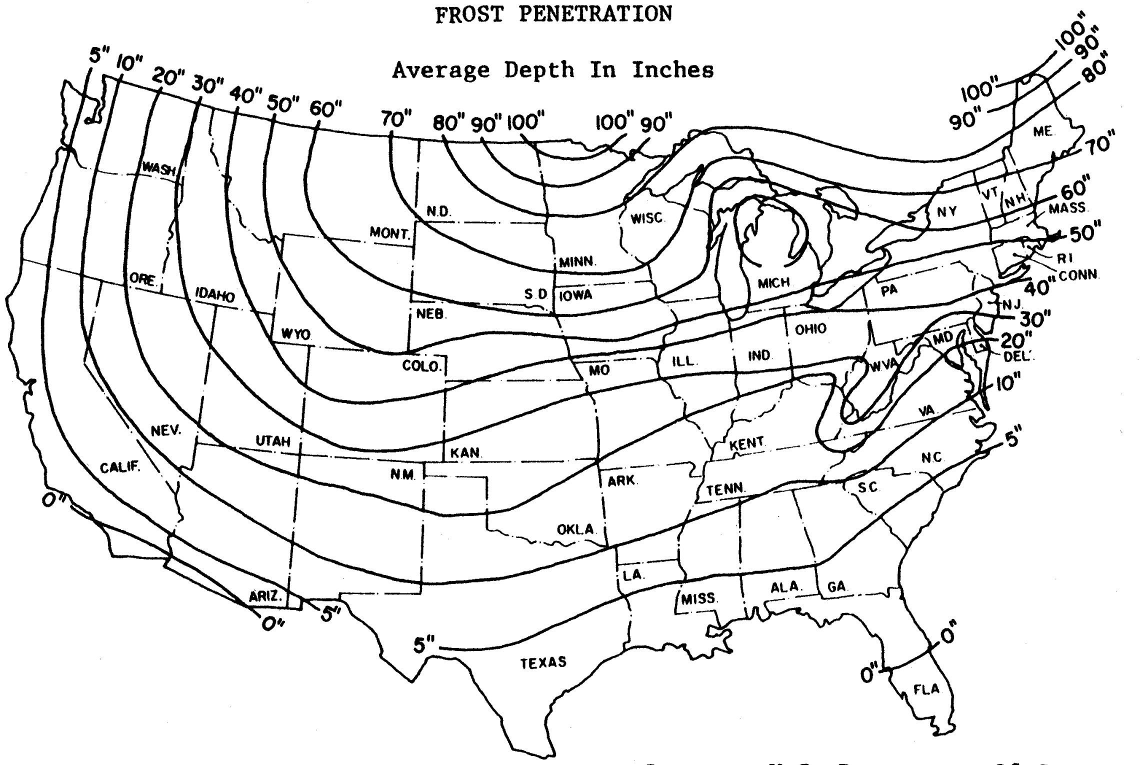
Oil & Gas Producers Underground Protection Service
(800) 925-0988

Oklahoma
Call Okie (800) 522-6543

State	Contact
Oregon	Utilities Underground Location Center (800) 424-5555 Douglas Utilities Coordinating Council (503) 673-6676 Josephine Utilities Coordinating Council (503) 476-6676 Rogue Basin Utility Coordinating Council (503) 779-6676 Utilities Notification Center (800) 332-2344
Pennsylvania	Pennsylvania One Call System Inc. (800) 242-1776
Rhode Island	Dig Safe – Rhode Island (800) 225-4977
South Carolina	Palmetto Utility Protection Service Inc. (800) 922-0983
South Dakota	South Dakota One Call (800) 781-7474
Tennessee	Tennessee One-Call System (800) 351-1111
Texas	Texas One Call System (800) 245-4545 Texas Excavation Safety System (800) 344-8377 Lone Star Notification Center (800) 669-8344
Utah	Blue Stakes Location Center (800) 662-4111
Vermont	Dig Safe – Vermont (800) 225-4977
Virginia	Miss Utility of Virginia (800) 552-7001 Miss Utility (800) 257-7777 Miss Utility of Delmarva (800) 441-8355
Washington	Utilities Underground Location Center (800) 424-5555 Grays Harbor & Pacific County Utility Coordinating Council (206) 535-3550 Utilities County of Cowlitz County (360) 425-2506 Chelan-Douglas Utilities Coordinating Council (509) 663-6111 Upper Yakima County Underground Utilities Council (800) 553-4344 Inland Empire Utility Coordinating Council (509) 456-8000 Palouse Empire Utilities Coordinating Council (800) 822-1974 Utilities Notification Center (800) 332-2344
West Virginia	Miss Utility of West Virginia Inc. (800) 245-4848
Wisconsin	Diggers Hotline Inc. (800) 242-8511
Wyoming	West Park Utility Coordinating Council (307) 587-4800 Call-In Dig-In Safety Council (800) 300-9811 Fremont County Utility Coordinating Council (800) 489-8023 Central Wyoming Utilities Coordinating Council (800) 759-8035 Southwest Wyoming One Call (307) 362-8888 Carbon County Utility Utility Coordinating Council (307) 324-6666 Albany County Utility Coordinating Council (307) 742-3615 Southeast Wyoming Utilities Coordinating Council (307) 638-6666 Wyoming One-Call (800) 348-1030 Utilities Underground Location Center (800) 454-5555 Converse County Utility Coordination Council (800) 562-5561

ATTACHMENT 2

FROST LINE PENETRATION DEPTHS BY GEOGRAPHIC LOCATION



ATTACHMENT 3
UTILITY CLEARANCE FORM

Client: ____________________ Project Name: ________________________________

Project No.: ______________________ Completed By: ________________________________

Location Name: _________________________ Work Date: ____________________________

Excavation Method/Overhead Equipment:____

1. Underground Utilities — Circle One

a)	Review of existing maps?	yes no N/A
b)	Interview local personnel?	yes no N/A
c)	Site visit and inspection?	yes no N/A
d)	Excavation areas marked in the field?	yes no N/A
e)	Utilities located in the field?	yes no N/A
f)	Located utilities marked/added to site maps?	yes no N/A
g)	Client contact notified Name ______________ Telephone:___________ Date: ______________	yes no N/A
g)	State One-Call agency called? Caller: ________________________________ Ticket Number: ___________________________ Date: ______________	yes no N/A
h)	Geophysical survey performed? Survey performed by:______________________ Method: ______________________________ Date: ______________	yes no N/A
i)	Hand augering performed? Augering completed by:____________________ Total depth:__________feet Date: _______	yes no N/A
j)	Trench/excavation probed? Probing completed by:_____________________ Depth/frequency: _________________________ Date: ______________	yes no N/A

2. Overhead Utilities — Present Absent

a)	Determination of nominal voltage	yes no N/A
b)	Marked on site maps	yes no N/A
c)	Necessary to lockout/insulate/re-route	yes no N/A
d)	Document procedures used to lockout/insulate/re-route	yes no N/A
e)	Minimum acceptable clearance (SOP Section 5.2): __________________	

3. Notes:

____
____
____

Approval:

______________________________________ ____________________
Site Manager/Field Operations Leader Date

c: PM/Project File
Program File

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1.0 PURPOSE

This procedure discusses the methods used to collect surface, near surface, and subsurface soil samples. Additionally, it describes the method for sampling of test pits and trenches to determine subsurface soil and rock conditions, and recover small-volume or bulk samples.

2.0 SCOPE

This procedure is applicable to the collection of surface, near surface and subsurface soils for laboratory testing, which are exposed through hand digging, hand augering, drilling, or machine excavating at hazardous substance sites.

3.0 GLOSSARY

Composite Sample - A composite sample exists as a combination of more than one sample at various locations and/or depths and times, which is homogenized and treated as one sample. This type of sample is usually collected when determination of an average waste concentration for a specific area is required. Composite samples are not to be collected for volatile organics analysis.

Grab Sample - One sample collected at one location and at one specific time.

Non-Volatile Sample - A non-volatile sample includes all other chemical parameters (e.g., semivolatiles, pesticides/PCBs, metals, etc.) and those engineering parameters that do not require undisturbed soil for their analysis.

Hand Auger - A sampling device used to extract soil from the ground in a relatively undisturbed form.

Thin-Walled Tube Sampler - A thin-walled metal tube (also called a Shelby tube) used to recover relatively undisturbed soil samples. These tubes are available in various sizes, ranging from 2 to 5 inches outside diameter (OD) and from 18 to 54 inches in length.

Split-Barrel Sampler - A steel tube, split in half lengthwise, with the halves held together by threaded collars at either end of the tube. Also called a split-spoon sampler, this device can be driven into resistant materials using a drive weight mounted in the drilling string. A standard split-barrel sampler is typically available in two common lengths, providing either 20-inch or 26-inch longitudinal clearance for obtaining 18-inch or 24-inch-long samples, respectively. These split-barrel samplers commonly range in size from 2-inch OD to 3-1/2 inch OD. The larger sizes are commonly used when a larger volume of sample material is required.

Test Pit and Trench - Open, shallow excavations, typically rectangular (if a test pit) or longitudinal (if a trench), excavated to determine the shallow subsurface conditions for engineering, geological, and soil chemistry exploration and/or sampling purposes. These pits are excavated manually or by machine (e.g., backhoe, clamshell, trencher excavator, or bulldozer).

Confined Space - As stipulated in 29 CFR 1910.146, a confined space means a space that: 1) is large enough and so configured that an employee can bodily enter and perform assigned work; 2) has limited or restricted means for entry or exit (for example tanks, vessels, silos, storage bins, hoppers, vaults, pits, and excavations); and 3) is not designed for continuous employee occupancy. TtNUS considers all confined space as permit-required confined spaces.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for determining sampling objectives, as well as, the field procedures used in the collection of soil samples. Additionally, in consultation with other project personnel (geologist, hydrogeologist, etc.), the Project Manager establishes the need for test pits or trenches, and determines their approximate locations and dimensions.

Site Safety Officer (SSO) - The SSO (or a qualified designee) is responsible for providing the technical support necessary to implement the project Health and Safety Plan. This will include (but not be limited to) performing air quality monitoring during sampling, boring and excavation activities, and to ensure that workers and offsite (downwind) individuals are not exposed to hazardous levels of airborne contaminants. The SSO/designee may also be required to advise the FOL on other safety-related matters regarding boring, excavation and sampling, such as mitigative measures to address potential hazards from unstable trench walls, puncturing of drums or other hazardous objects, etc.

Field Operations Leader (FOL) - The FOL is responsible for finalizing the location of surface, near surface, and subsurface (hand and machine borings, test pits/trenches) soil samples. He/she is ultimately responsible for the sampling and backfilling of boreholes, test pits and trenches, and for adherence to OSHA regulations during these operations.

Project Geologist/Sampler - The project geologist/sampler is responsible for the proper acquisition of soil samples and the completion of all required paperwork (i.e., sample log sheets, field notebook, boring logs, test pit logs, container labels, custody seals, and chain-of-custody forms).

Competent Person - A Competent Person, as defined in 29 CFR 1929.650 of Subpart P - Excavations, means one who is capable of identifying existing and predictable hazards in the surroundings, or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them.

5.0 PROCEDURES

5.1 Overview

Soil sampling is an important adjunct to groundwater monitoring. Sampling of the soil horizons above the groundwater table can detect contaminants before they have migrated into the water table, and can establish the amount of contamination sorbed on aquifer solids that have the potential of contributing to groundwater contamination.

Soil types can vary considerably on a hazardous waste site. These variations, along with vegetation, can affect the rate of contaminant migration through the soil. It is important, therefore, that a detailed record be maintained during the sampling operations, particularly noting the location, depth, and such characteristics as grain size, color, and odor. Subsurface conditions are often stable on a daily basis and may demonstrate only slight seasonal variation especially with respect to temperature, available oxygen and light penetration. Changes in any of these conditions can radically alter the rate of chemical reactions or the associated microbiological community, thus further altering specific site conditions. As a result, samples must be kept at their at-depth temperature or lower, protected from direct light, sealed tightly in approved glass containers, and be analyzed as soon as possible.

The physical properties of the soil, its grain size, cohesiveness, associated moisture, and such factors as depth to bedrock and water table, will limit the depth from which samples can be collected and the method required to collect them. Often this information on soil properties can be obtained from published soil surveys available through the U.S. Geological Surveys and other government or farm agencies. It is the intent of this procedure to present the most commonly employed soil sampling methods used at hazardous waste sites.

5.2 Soil Sample Collection

5.2.1 Procedure for Collecting Soil Samples for Volatile Organic Compounds

The above described traditional sampling techniques, used for the collection of soil samples for volatile organic analysis, have recently been evaluated by the scientific community and determined to be ineffective in producing accurate results (biased low) due to the loss of volatile organics in the sampling stages and microbial degradation of aromatic volatiles. One of the newly adopted sampling procedures for collecting soil samples includes the field preservation of samples with methanol or sodium bisulfate to minimize volatilization and biodegradation. These preservation methods may be performed either in the field or laboratory, depending on the sampling methodology employed.

Soil samples to be preserved by the laboratory are currently being performed using method SW-846, 5035. Laboratories are currently performing low level analyses (sodium bisulfate preservation) and high level analyses (methanol preservation) depending on the end users needs.

It should be noted that a major disadvantage of the methanol preservation method is that the laboratory reporting limits will be higher than conventional testing. The reporting levels using the new method for most analytes are 0.5 µg/g for GC/MS and 0.05 µg/g for GC methods.

The alternative preservation method for collecting soil samples is with sodium bisulfate. This method is more complex to perform in the field and therefore is not preferred for field crews. It should also be noted that currently, not all laboratories have the capabilities to perform this analysis. The advantage to this method is that the reporting limits (0.001 µg/g for GC/PID or GC/ELCD, or 0.010 for GC/MS) are lower than those described above.

The following procedures outline the necessary steps for collecting soil samples to be preserved at the laboratory, and for collecting soil samples to be preserved in the field with methanol or sodium bisulfate.

5.2.1.1 Soil Samples to be Preserved at the Laboratory

Soil samples collected for volatile organics that are to be preserved at the laboratory will be obtained using a hermetically sealed sample vial such as an EnCore™ sampler. Each sample will be obtained using a reusable sampling handle provided with the EnCore™ sampler. The sample is collected by pushing the EnCore™ sampler directly into the soil, ensuring that the sampler is packed tight with soil, leaving zero headspace. Using this type of sampling device eliminates the need for field preservation and the shipping restrictions associated with preservatives. A complete set of instructions is included with each Encore™ sampler shipment by the manufacturer.

Once the sample is collected, it should be placed on ice immediately and shipped to the laboratory within 48 hours (following the chain-of-custody and documentation procedures outlined in SOP SA-6.1). Samples must be preserved by the laboratory within 48 hours of sample collection.

If the lower detection limits are necessary, an option would be to collect several EnCore™ samplers at a given sample location. Send all samplers to the laboratory and the laboratory can perform the required preservation and analyses.

5.2.1.2 Soil Samples to be Preserved in the Field

Soil samples preserved in the field may be prepared for analyses using both the low-level (sodium bisulfate preservation) method and medium-level (methanol preservation) method.

Methanol Preservation (Medium Level):

Soil samples to be preserved in the field with methanol will utilize 40-60 mL glass vials with septum lids. Each sample bottle will be filled with 25 mL of demonstrated analyte-free purge and trap grade methanol. Bottles may be prespiked with methanol in the laboratory or prepared in the field.

Soil will be collected with the use of a decontaminated (or disposable), small-diameter coring device such as a disposable tube/plunger-type syringe with the tip cut off. The outside diameter of the coring device must be smaller than the inside diameter of the sample bottle neck.

A small electronic balance or manual scale will be necessary for measuring the volume of soil to be added to the methanol preserved sample bottle. Calibration of the scale should be performed prior to use and intermittently throughout the day according to the manufacturers requirements.

The sample should be collected by pulling the plunger back and inserting the syringe into the soil to be sampled. The top several inches of soil should be removed before collecting the sample. Approximately 10 grams $\pm$2g (8-12 grams) of soil should be collected. The sample should be weighed and adjusted until obtaining the required amount of sample. The sample weight should be recorded to the nearest 0.01 gram in the field logbook and/or sample log sheet. The soil should then be extruded into the methanol preserved sample bottle taking care not to contact the sample container with the syringe. The threads of the bottle and cap must be free of soil particles.

After capping the bottle, swirl the sample (do not shake) in the methanol and break up the soil such that all of the soil is covered with methanol. Place the sample on ice immediately and prepare for shipment to the laboratory as described in SOP SA-6.1.

Sodium Bisulfate Preservation (Low Level):

Samples to be preserved using the sodium bisulfate method are to be prepared as follows:

Add 1 gram of sodium bisulfate to 5 mL of laboratory grade deionized water in a 40-60 mL glass vial with septum lid. Bottles may be prespiked in the laboratory or prepared in the field. The soil sample should be collected in a manner as described above and added to the sample container. The sample should be weighed to the nearest 0.01 gram as described above and recorded in the field logbook or sample log sheet.

Care should be taken when adding the soil to the sodium bisulfate solution. A chemical reaction of soils containing carbonates (limestone) may cause the sample to effervesce or the vial to possibly explode.

When preparing samples using the sodium bisulfate preservation method, duplicate samples must be collected using the methanol preservation method on a one for one sample basis. The reason for this is because it is necessary for the laboratory to perform both the low level and medium level analyses. Place the sample on ice immediately and prepare for shipment to the laboratory as described in SOP SA-6.1.

If the lower detection limits are necessary, an option to field preserving with sodium bisulfate would be to collect 3 EnCore™ samplers at a given sample location. Send all samplers to the laboratory and the laboratory can perform the required preservation and analyses.

5.2.2 Procedure for Collecting Non-Volatile Soil Samples

Non-volatile soil samples may be collected as either grab or composite samples. The non-volatile soil sample is thoroughly mixed in a stainless steel or disposable, inert plastic tray, using a stainless steel trowel or other approved tool, then transferred into the appropriate sample container(s). Head space is permitted in a non-volatile soil sample container to allow for sample expansion.

5.2.3 Procedure for Collecting Undisturbed Soil Samples (ASTM D1587-83)

When it is necessary to acquire undisturbed samples of soil for purposes of engineering parameter analysis (e.g., permeability), a thin-walled, seamless tube sampler (Shelby tube) will be employed. The following method will be used:

1. Remove all surface debris (e.g., vegetation, roots, twigs, etc.) from the specific sampling location and drill and clean out the borehole to the sampling depth, being careful to minimize the chance for disturbance of the material to be sampled. In saturated material, withdraw the drill bit slowly to prevent loosening of the soil around the borehole and to maintain the water level in the hole at or above groundwater level.

2. The use of bottom discharge bits or jetting through an open-tube sampler to clean out the borehole shall not be allowed. Use of any side-discharge bits is permitted.

3. A stationary piston-type sampler may be required to limit sample disturbance and aid in retaining the sample. Either the hydraulically operated or control rod activated-type of stationary piston sampler may be used. Prior to inserting the tube sampler into the borehole, check to ensure that the sampler head contains a check valve. The check valve is necessary to keep water in the rods from pushing the sample out the tube sampler during sample withdrawal and to maintain a suction within the tube to help retain the sample.

4. To minimize chemical reaction between the sample and the sampling tube, brass tubes may be required, especially if the tube is stored for an extended time prior to testing. While steel tubes coated with shellac are less expensive than brass, they're more reactive, and shall only be used when the sample will be tested within a few days after sampling or if chemical reaction is not anticipated. With the sampling tube resting on the bottom of the hole and the water level in the boring at groundwater level or above, push the tube into the soil by a continuous and rapid motion, without impacting or twisting. In no case shall the tube be pushed farther than the length provided for the soil sample. Allow about 3 inches in the tube for cuttings and sludge.

5. Upon removal of the sampling tube from the hole, measure the length of sample in the tube and also the length penetrated. Remove disturbed material in the upper end of the tube and measure the length of sample again. After removing at least an inch of soil from the lower end and after inserting an impervious disk, seal both ends of the tube with at least a 1/2-inch thickness of wax applied in a way that will prevent the wax from entering the sample. Clean filler must be placed in voids at either end of the tube prior to sealing with wax. Place plastic caps on the ends of the sample tube, tape the caps in place, and dip the ends in wax.

6. Affix label(s) to the tube as required and record sample number, depth, penetration, and recovery length on the label. Mark the "up" direction on the side of the tube with indelible ink, and mark the end of the sample. Complete Chain-of-Custody (see SOP SA-6.3) and other required forms (including Attachment A of this SOP). Do not allow tubes to freeze, and store the samples vertically with the same orientation they had in the ground, (i.e., top of sample is up) in a cool place out of the sun at all times. Ship samples protected with suitable resilient packing material to reduce shock, vibration, and disturbance.

Thin-walled undisturbed tube samplers are restricted in their usage by the consistency of the soil to be sampled. Often, very loose and/or wet samples cannot be retrieved by the samplers, and soils with a consistency in excess of very stiff cannot be penetrated by the sampler. Devices such as Dennison or Pitcher core samplers can be used to obtain undisturbed samples of stiff soils. Using these devices normally increases sampling costs, and therefore their use shall be weighed against the need for acquiring an undisturbed sample.

5.3 Surface Soil Sampling

The simplest, most direct method of collecting surface soil samples (most commonly collected to a depth of 6 inches) for subsequent analysis is by use of a stainless steel trowel. Surface soils are considered 0-12 inches bgs.

In general, the following equipment is necessary for obtaining surface soil samples:

- Stainless steel or pre-cleaned disposable trowel.
- Real-time air monitoring instrument (e.g., PID, FID, etc.).
- Latex gloves.
- Required Personal Protective Equipment (PPE).
- Required paperwork (see SOP SA-6.3 and Attachment A of this SOP).
- Required decontamination equipment.
- Required sample container(s).
- Wooden stakes or pin flags.
- Sealable polyethylene bags (i.e., Ziploc® baggies).
- Heavy duty cooler.
- Ice.
- Chain-of-custody records and custody seals.

When acquiring surface soil samples, the following procedure shall be used:

1. Carefully remove vegetation, roots, twigs, litter, etc., to expose an adequate soil surface area to accommodate sample volume requirements.

2. Using a decontaminated stainless steel trowel, follow the procedure cited in Section 5.2.1 for collecting a volatile soil sample. Surface soil samples for volatile organic analysis should be collected from 6-12 inches bgs only.

3. Thoroughly mix (in-situ) a sufficient amount of soil to fill the remaining sample containers and transfer the sample into those containers utilizing the same stainless steel trowel employed above. Cap and securely tighten all sample containers.

4. Affix a sample label to each container. Be sure to fill out each label carefully and clearly, addressing all the categories described in SOP SA-6.3.

5. Proceed with the handling and processing of each sample container as described in SOP SA-6.2.

5.4 Near-Surface Soil Sampling

Collection of samples from near the surface (depth of 6-18 inches) can be accomplished with tools such as shovels and stainless steel or pre-cleaned disposable trowels.

The following equipment is necessary to collect near surface soil samples:

- Clean shovel.
- The equipment listed under Section 5.3 of this procedure.
- Hand auger.

To obtain near-surface soil samples, the following protocol shall be observed:

1. With a clean shovel, make a series of vertical cuts to the depth required in the soil to form a square approximately 1 foot by 1 foot.

2. Lever out the formed plug and scrape the bottom of the freshly dug hole with a decontaminated stainless steel or pre-cleaned disposable trowel to remove any loose soil.

3. Follow steps 2 through 5 listed under Section 5.3 of this procedure.

5.5 Subsurface Soil Sampling With a Hand Auger

A hand augering system generally consists of a variety of all stainless steel bucket bits (i.e., cylinders 6-1/2" long, and 2-3/4", 3-1/4", and 4" in diameter), a series of extension rods (available in 2', 3', 4' and 5' lengths), and a cross handle. A larger diameter bucket bit is commonly used to bore a hole to the desired sampling depth and then withdrawn. In turn, the larger diameter bit is replaced with a smaller diameter bit, lowered down the hole, and slowly turned into the soil at the completion depth (approximately 6 inches). The apparatus is then withdrawn and the soil sample collected.

The hand auger can be used in a wide variety of soil conditions. It can be used to sample soil both from the surface, or to depths in excess of 12 feet. However, the presence of rock layers and the collapse of the borehole normally contribute to its limiting factors.

To accomplish soil sampling using a hand augering system, the following equipment is required:

- Complete hand auger assembly (variety of bucket bit sizes).
- Stainless steel mixing bowls.
- The equipment listed under Section 5.3 of this procedure.

To obtain soil samples using a hand auger, the following procedure shall be followed:

1. Attach a properly decontaminated bucket bit to a clean extension rod and further attach the cross handle to the extension rod.

2. Clear the area to be sampled of any surface debris (vegetation, twigs, rocks, litter, etc.).

3. Begin augering (periodically removing accumulated soils from the bucket bit) and add additional rod extensions as necessary. Also, note (in a field notebook, boring log, and/or on standardized data sheets) any changes in the color, texture or odor of the soil.

4. After reaching the desired depth, slowly and carefully withdraw the apparatus from the borehole.

5. Remove the soiled bucket bit from the rod extension and replace it with another properly decontaminated bucket bit. The bucket bit used for sampling is commonly smaller in diameter than the bucket bit employed to initiate the borehole.

6. Carefully lower the apparatus down the borehole. Care must be taken to avoid scraping the borehole sides.

7. Slowly turn the apparatus until the bucket bit is advanced approximately 6 inches.

8. Discard the top of the core (approximately 1"), which represents any loose material collected by the bucket bit before penetrating the sample material.

9. Fill volatile sample container(s), using a properly decontaminated stainless steel trowel, with sample material directly from the bucket bit. Refer to Section 5.2.1 of this procedure.

10. Utilizing the above trowel, remove the remaining sample material from the bucket bit and place into a properly decontaminated stainless steel mixing bowl and thoroughly homogenize the sample material prior to filling the remaining sample containers. Refer to Section 5.2.2 of this procedure.

11. Follow steps 4 and 5 listed under Section 5.3 of this procedure.

5.6 Subsurface Soil Sampling With a Split-Barrel Sampler (ASTM D1586-84)

Split-barrel (split-spoon) samplers consist of a heavy carbon steel or stainless steel sampling tube that can be split into two equal halves to reveal the soil sample (see Attachment B). A drive head is attached to the upper end of the tube and serves as a point of attachment for the drill rod. A removable tapered nosepiece/drive shoe attaches to the lower end of the tube and facilitates cutting. A basket-like sample retainer can be fitted to the lower end of the split tube to hold loose, dry soil samples in the tube when the sampler is removed from the drill hole. This split-barrel sampler is made to be attached to a drill rod and forced into the ground by means of a 140-lb. or larger casing driver.

Split-barrel samplers are used to collect soil samples from a wide variety of soil types and from depths greater than those attainable with other soil sampling equipment.

The following equipment is used for obtaining split-barrel samples:

- Drilling equipment (provided by subcontractor).

- Split-barrel samplers (O.D. 2 inches, I.D. 1-3/8 inches, either 20 inches or 26 inches long); Larger O.D. samplers are available if a larger volume of sample is needed.

- Drive weight assembly, 140-lb. weight, driving head and guide permitting free fall of 30 inches.

- Stainless steel mixing bowls.

- Equipment listed under Section 5.3 of this procedure.

The following steps shall be followed to obtain split-barrel samples:

1. Remove the drive head and nosepiece, and open the sampler to reveal the soil sample. Immediately scan the sample core with a real-time air monitoring instrument (e.g., FID, PID, etc.). Carefully separate the soil core, with a decontaminated stainless steel knife or trowel, at about 6-inch intervals while scanning the center of the core for elevated readings. Also scan stained soil, soil lenses, and anomalies (if present), and record readings.

2. Collect the volatile sample from the center of the core where elevated readings occurred. If no elevated readings where encountered the sample material should still be collected from the core's

center (this area represents the least disturbed area with minimal atmospheric contact). Refer to Section 5.2.1 of this procedure.

3. Using the same trowel, remove remaining sample material from the split-barrel sampler (except for the small portion of disturbed soil usually found at the top of the core sample) and place the soil into a decontaminated stainless steel mixing bowl. Thoroughly homogenize the sample material prior to filling the remaining sample containers. Refer to Section 5.2.2 of this procedure.

4. Follow steps 4 and 5 listed under Section 5.3 of this procedure.

5.7 Subsurface Sol Sampling Using Direct Push Technology

Subsurface soil samples can be collected to depths of 40+ feet using direct push technology (DPT). DPT equipment, responsibilities, and procedures are described in SOP SA-2.5.

5.8 Excavation and Sampling of Test Pits and Trenches

5.8.1 Applicability

This subsection presents routine test pit or trench excavation techniques and specialized techniques that are applicable under certain conditions.

During the excavation of trenches or pits at hazardous waste sites, several health and safety concerns arise which control the method of excavation. No personnel shall enter any test pit or excavation over 4 feet deep except as a last resort, and then only under direct supervision of a Competent Person (as defined in 29 CFR 1929.650 of Subpart P - Excavations). Whenever possible, all required chemical and lithological samples should be collected using the excavator bucket or other remote sampling apparatus. If entrance is still required, all test pits or excavations must be stabilized by bracing the pit sides using specifically designed wooden or steel support structures. Personnel entering the excavation may be exposed to toxic or explosive gases and oxygen-deficient environments. Any entry may constitute a Confined Space and must be done in conformance with all applicable regulations. In these cases, substantial air monitoring is required before entry, and appropriate respiratory gear and protective clothing is mandatory. There must be at least two persons present at the immediate site before entry by one of the investigators. The reader shall refer to OSHA regulations 29 CFR 1926, 29 CFR 1910.120, 29 CFR 1910.134, and 29 CFR 1910.146.

Excavations are generally not practical where a depth of more than about 15 feet is desired, and they are usually limited to a few feet below the water table. In some cases, a pumping system may be required to control water levels within the pit, providing that pumped water can be adequately stored or disposed. If data on soils at depths greater than 15 feet are required, the data are usually obtained through test borings instead of test pits.

In addition, hazardous wastes may be brought to the surface by excavation equipment. This material, whether removed from the site or returned to the subsurface, must be properly handled according to any and all applicable federal, state, and local regulations.

5.8.2 Test Pit and Trench Excavation

These procedures describe the methods for excavating and logging test pits and trenches excavated to determine subsurface soil and rock conditions. Test pit operations shall be logged and documented (see Attachment C).

Test pits and trenches may be excavated by hand or by power equipment to permit detailed description of the nature and contamination of the in-situ materials. The size of the excavation will depend primarily on the following:

- The purpose and extent of the exploration.
- The space required for efficient excavation.
- The chemicals of concern.
- The economics and efficiency of available equipment.

Test pits normally have a cross section that is 4 to 10 feet square; test trenches are usually 3 to 6 feet wide and may be extended for any length required to reveal conditions along a specific line. The following table, which is based on equipment efficiencies, gives a rough guide for design consideration:

Equipment	Typical Widths, in Feet
Trenching machine	2
Backhoe	2-6
Track dozer	10
Track loader	10
Excavator	10
Scraper	20

The lateral limits of excavation of trenches and the position of test pits shall be carefully marked on area base maps. If precise positioning is required to indicate the location of highly hazardous waste materials, nearby utilities, or dangerous conditions, the limits of the excavation shall be surveyed. Also, if precise determination of the depth of buried materials is needed for design or environmental assessment purposes, the elevation of the ground surface at the test pit or trench location shall also be determined by survey. If the test pit/trench will not be surveyed immediately, it shall be backfilled and its position identified with stakes placed in the ground at the margin of the excavation for later surveying.

The construction of test pits and trenches shall be planned and designed in advance as much as possible. However, field conditions may necessitate revisions to the initial plans. The final depth and construction method shall be determined by the field geologist. The actual layout of each test pit, temporary staging area, and spoils pile will be predicated based on site conditions and wind direction at the time the test pit is made. Prior to excavation, the area can be surveyed by magnetometer or metal detector to identify the presence of underground utilities or drums.

As mentioned previously, no personnel shall enter any test pit or excavation except as a last resort, and then only under direct supervision of a Competent Person. If entrance is still required, Occupational Safety and Health Administration (OSHA) requirements must be met (e.g., walls must be braced with wooden or steel braces, ladders must be in the hole at all times, and a temporary guardrail must be placed along the surface of the hole before entry). It is emphasized that the project data needs should be structured such that required samples can be collected without requiring entrance into the excavation. For example, samples of leachate, groundwater, or sidewall soils can be taken with telescoping poles, etc.

Dewatering may be required to assure the stability of the side walls, to prevent the bottom of the pit from heaving, and to keep the excavation dry. This is an important consideration for excavations in cohesionless material below the groundwater table. Liquids removed as a result of dewatering operations must be handled as potentially contaminated materials. Procedures for the collection and disposal of such materials should be discussed in the site-specific project plans.

5.8.3 Sampling in Test Pits and Trenches

5.8.3.1 General

Test pits and trenches are usually logged as they are excavated. Records of each test pit/trench will be made as presented in Attachment C. These records include plan and profile sketches of the test pit/trench showing materials encountered, their depth and distribution in the pit/trench, and sample locations. These records also include safety and sample screening information.

Entry of test pits by personnel is extremely dangerous, shall be avoided unless absolutely necessary, and can occur only after all applicable Health and Safety and OSHA requirements have been met.

The final depth and type of samples obtained from each test pit will be determined at the time the test pit is excavated. Sufficient samples are usually obtained and analyzed to quantify contaminant distribution as a function of depth for each test pit. Additional samples of each waste phase and any fluids encountered in each test pit may also be collected.

In some cases, samples of soil may be extracted from the test pit for reasons other than waste sampling and chemical analysis, for instance, to obtain geotechnical information. Such information would include soil types, stratigraphy, strength, etc., and could therefore entail the collection of disturbed (grab or bulk) or relatively undisturbed (hand-carved or pushed/driven) samples, which can be tested for geotechnical properties. The purposes of such explorations are very similar to those of shallow exploratory or test borings, but often test pits offer a faster, more cost-effective method of sampling than installing borings.

5.8.3.2 Sampling Equipment

The following equipment is needed for obtaining samples for chemical or geotechnical analysis from test pits and trenches:

- Backhoe or other excavating machinery.
- Shovels, picks, hand augers, and stainless steel trowels/disposable trowels.
- Sample container - bucket with locking lid for large samples; appropriate bottleware for chemical or geotechnical analysis samples.
- Polyethylene bags for enclosing sample containers; buckets.
- Remote sampler consisting of 10-foot sections of steel conduit (1-inch-diameter), hose clamps and right angle adapter for conduit (see Attachment D).

5.8.3.3 Sampling Methods

The methods discussed in this section refer to test pit sampling from grade level. If test pit entry is required, see Section 5.8.3.4.

- Excavate trench or pit in several depth increments. After each increment, the operator will wait while the sampler inspects the test pit from grade level to decide if conditions are appropriate for sampling. (Monitoring of volatiles by the SSO will also be used to evaluate the need for sampling.) Practical depth increments range from 2 to 4 feet.

- The backhoe operator, who will have the best view of the test pit, will immediately cease digging if:

  - Any fluid phase or groundwater seepage is encountered in the test pit.
  - Any drums, other potential waste containers, obstructions or utility lines are encountered.
  - Distinct changes of material are encountered.

This action is necessary to permit proper sampling of the test pit and to prevent a breach of safety protocol. Depending upon the conditions encountered, it may be required to excavate more slowly and carefully with the backhoe.

For obtaining test pit samples from grade level, the following procedure shall be followed:

- Remove loose material to the greatest extent possible with backhoe.

- Secure walls of pit if necessary. (There is seldom any need to enter a pit or trench which would justify the expense of shoring the walls. All observations and samples should be taken from the ground surface.)

- Samples of the test pit material are to be obtained either directly from the backhoe bucket or from the material once it has been deposited on the ground. The sampler or Field Operations Leader directs the backhoe operator to remove material from the selected depth or location within the test pit/trench. The bucket is brought to the surface and moved away from the pit. The sampler and/or SSO then approaches the bucket and monitors its contents with a photoionization or flame ionization detector. The sample is collected from the center of the bucket or pile and placed in sample containers using a decontaminated stainless steel trowel or disposable spatula.

- If a composite sample is desired, several depths or locations within the pit/trench are selected and a bucket is filled from each area. It is preferable to send individual sample bottles filled from each bucket to the laboratory for compositing under the more controlled laboratory conditions. However, if compositing in the field is required, each sample container shall be filled from materials that have been transferred into a mixing bucket and homogenized. Note that homogenization/compositing is not applicable for samples to be subjected to volatile organic analysis.

- Using the remote sampler shown in Attachment D, samples can be taken at the desired depth from the side wall or bottom of the pit. The face of the pit/trench shall first be scraped (using a long-handled shovel or hoe) to remove the smeared zone that has contacted the backhoe bucket. The sample shall then be collected directly into the sample jar, by scraping with the jar edge, eliminating the need to utilize samplers and minimizing the likelihood of cross-contamination. The sample jar is then capped, removed from the assembly, and packaged for shipment.

- Complete documentation as described in SOP SA-6.3 and Attachment C of this SOP.

5.8.3.4 <u>In-Pit Sampling</u>

Under rare conditions, personnel may be required to enter the test pit/trench. This is necessary only when soil conditions preclude obtaining suitable samples from the backhoe bucket (e.g., excessive mixing of soils or wastes within the test pit/trench) or when samples from relatively small discrete zones within the test pit are required. This approach may also be necessary to sample any seepage occurring at discrete levels or zones in the test pit that are not accessible with remote samplers.

In general, personnel shall sample and log pits and trenches from the ground surface, except as provided for by the following criteria:

- There is no practical alternative means of obtaining such data.

- The Site Safety Officer and Competent Person determines that such action can be accomplished without breaching site safety protocol. This determination will be based on actual monitoring of the pit/trench after it is dug (including, at a minimum, measurements of volatile organics, explosive gases and available oxygen).

- A Company-designated Competent Person determines that the pit/trench is stable or is made stable (by grading the sidewalls or using shoring) prior to entrance of any personnel. OSHA requirements must be strictly observed.

If these conditions are satisfied, one person will enter the pit/trench. On potentially hazardous waste sites, this individual will be dressed in safety gear as required by the conditions in the pit. He/she will be affixed to a safety rope and continuously monitored while in the pit.

A second individual will be fully dressed in protective clothing including a self-contained breathing device and on standby during all pit entry operations. The individual entering the pit will remain therein for as brief a period as practical, commensurate with performance of his/her work. After removing the smeared zone, samples shall be obtained with a decontaminated trowel or spoon. As an added precaution, it is advisable to keep the backhoe bucket in the test pit when personnel are working below grade. Such personnel can either stand in or near the bucket while performing sample operations. In the event of a cave-in they can either be lifted clear in the bucket, or at least climb up on the backhoe arm to reach safety.

5.8.3.5 Geotechnical Sampling

In addition to the equipment described in Section 5.8.3.2, the following equipment is needed for geotechnical sampling:

- Soil sampling equipment, similar to that used in shallow drilled boring (i.e., open tube samplers), which can be pushed or driven into the floor of the test pit.

- Suitable driving (i.e., a sledge hammer) or pushing (i.e., the backhoe bucket) equipment which is used to advance the sampler into the soil.

- Knives, spatulas, and other suitable devices for trimming hand-carved samples.

- Suitable containers (bags, jars, tubes, boxes, etc.), labels, wax, etc. for holding and safely transporting collected soil samples.

- Geotechnical equipment (pocket penetrometer, torvane, etc.) for field testing collected soil samples for classification and strength properties.

Disturbed grab or bulk geotechnical soil samples may be collected for most soils in the same manner as comparable soil samples for chemical analysis. These collected samples may be stored in jars or plastic-lined sacks (larger samples), which will preserve their moisture content. Smaller samples of this type are usually tested for their index properties to aid in soil identification and classification, while larger bulk samples are usually required to perform compaction tests.

Relatively undisturbed samples are usually extracted in cohesive soils using open tube samplers, and such samples are then tested in a geotechnical laboratory for their strength, permeability and/or compressibility. The techniques for extracting and preserving such samples are similar to those used in performing Shelby tube sampling in borings, except that the sampler is advanced by hand or backhoe, rather than by a drill rig. Also, the sampler may be extracted from the test pit by excavation around the sampler when it is difficult to pull it out of the ground. If this excavation requires entry of the test pit, the requirements described in Section 5.8.3.4 of this procedure must be followed. The open tube sampler shall be pushed or driven vertically into the floor or steps excavated in the test pit at the desired sampling elevations. Extracting tube samples horizontally from the walls of the test pit is not appropriate, because the sample will not have the correct orientation.

A sledge hammer or the backhoe may be used to drive or push the sampler or tube into the ground. Place a piece of wood over the top of the sampler or sampling tube to prevent damage during driving/pushing of the sample. Pushing the sampler with a constant thrust is always preferable to driving it with repeated blows, thus minimizing disturbance to the sample. If the sample cannot be extracted by rotating it at least two revolutions (to shear off the sample at the bottom), hand-excavate to remove the soil from around the sides of the sampler. If hand-excavation requires entry of the test pit, the requirements in Section 5.8.3.4 of this procedure must be followed. Prepare, label, pack and transport the sample in the required manner, as described in SOP SA-6.3 and SA-6.1.

5.8.4 Backfilling of Trenches and Test Pits

All test pits and excavations must be either backfilled, covered, or otherwise protected at the end of each day. No excavations shall remain open during non-working hours unless adequately covered or otherwise protected.

Before backfilling, the onsite crew shall photograph all significant features exposed by the test pit and trench and shall include in the photograph a scale to show dimensions. Photographs of test pits shall be marked to include site number, test pit number, depth, description of feature, and date of photograph. In addition, a geologic description of each photograph shall be entered in the site logbook. All photographs shall be indexed and maintained as part of the project file for future reference.

After inspection, backfill material shall be returned to the pit under the direction of the FOL.

If a low permeability layer is penetrated (resulting in groundwater flow from an upper contaminated flow zone into a lower uncontaminated flow zone), backfill material must represent original conditions or be impermeable. Backfill could consist of a soil-bentonite mix prepared in a proportion specified by the FOL (representing a permeability equal to or less than original conditions). Backfill can be covered by "clean" soil and graded to the original land contour. Revegetation of the disturbed area may also be required.

5.9 Records

The appropriate sample log sheet (see Attachment A of this SOP) must be completed by the site geologist/sampler. All soil sampling locations should be documented by tying in the location of two or more nearby permanent landmarks (building, telephone pole, fence, etc.) or obtaining GPS coordinates; and shall be noted on the appropriate sample log sheet, site map, or field notebook. Surveying may also be necessary, depending on the project requirements.

Test pit logs (see Attachment C of this SOP) shall contain a sketch of pit conditions. In addition, at least one photograph with a scale for comparison shall be taken of each pit. Included in the photograph shall be a card showing the test pit number. Boreholes, test pits and trenches shall be logged by the field geologist in accordance with SOP GH-1.5.

Other data to be recorded in the field logbook include the following:

- Name and location of job.
- Date of boring and excavation.

- Approximate surface elevation.
- Total depth of boring and excavation.
- Dimensions of pit.
- Method of sample acquisition.
- Type and size of samples.
- Soil and rock descriptions.
- Photographs.
- Groundwater levels.
- Organic gas or methane levels.
- Other pertinent information, such as waste material encountered.

6.0 REFERENCES

American Society for Testing and Materials, 1987. ASTM Standards D1587-83 and D1586-84. ASTM Annual Book of Standards. ASTM. Philadelphia, Pennsylvania. Volume 4.08.

NUS Corporation, 1986. Hazardous Material Handling Training Manual.

NUS Corporation and CH2M Hill, August, 1987. Compendium of Field Operation Methods. Prepared for the U.S. EPA.

OSHA, Excavation, Trenching and Shoring 29 CFR 1926.650-653.

OSHA, Confined Space Entry 29 CFR 1910.146.

ATTACHMENT A
SOIL & SEDIMENT SAMPLE LOG SHEET

Tetra Tech NUS, Inc.

SOIL & SEDIMENT SAMPLE LOG SHEET

Page___ of ___

Project Site Name: ____________
Project No.: ____________

[] Surface Soil
[] Subsurface Soil
[] Sediment
[] Other: ____________
[] QA Sample Type: ____________

Sample ID No.: ____________
Sample Location: ____________
Sampled By: ____________
C.O.C. No.: ____________

Type of Sample:
[] Low Concentration
[] High Concentration

GRAB SAMPLE DATA:

Date:	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Time:			
Method:			
Monitor Reading (ppm):			

COMPOSITE SAMPLE DATA:

Date:	Time	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Method:				
Monitor Readings (Range in ppm):				

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other

OBSERVATIONS / NOTES:

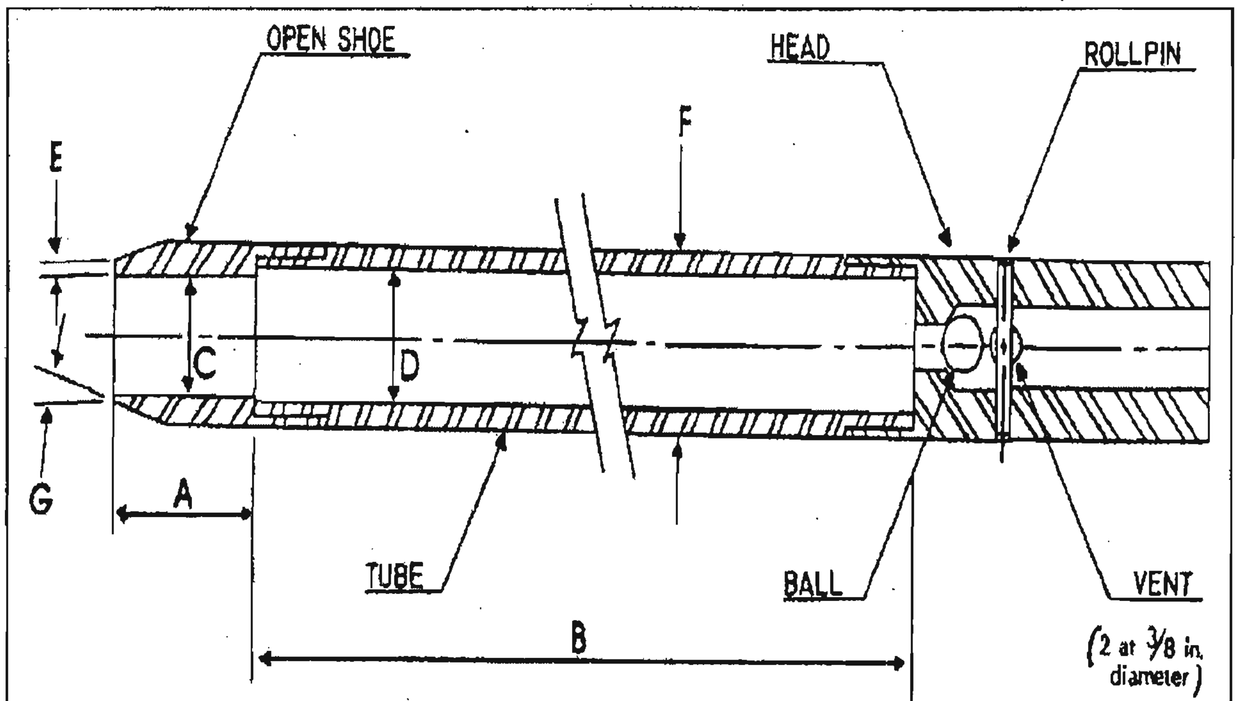
MAP:

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

ATTACHMENT B
SPLIT-SPOON SAMPLER



A = 1.0 to 2.0 in. (25 to 50 mm)
B = 18.0 to 30.0 in. (0.457 to 0.762 m)
C = 1.375 ± 0.005 in. (34.93 ± 0.13 mm)
D = 1.50 ± 0.05 – 0.00 in. (38.1 ± 1.3 – 0.0 mm)
E = 0.10 ± 0.02 in. (2.54 ± 0.25 mm)
F = 2.00 ± 0.05 – 0.00 in. (50.8 ± 1.3 – 0.0 mm)
G = 16.0° to 23.0°

The 1½ in. (38 mm) inside diameter split barrel may be used with a 16-gage wall thickness split liner. The penetrating end of the drive shoe may be slightly rounded. Metal or plastic retainers may be used to retain soil samples.

ATTACHMENT C
TEST PIT LOG

Tetra Tech NUS, Inc.

TEST PIT LOG

Page ___ of ___

PROJECT NAME: ______________ TEST PIT No.: ______________
PROJECT NUMBER: ______________ DATE: ______________
LOCATION: ______________ GEOLOGIST: ______________

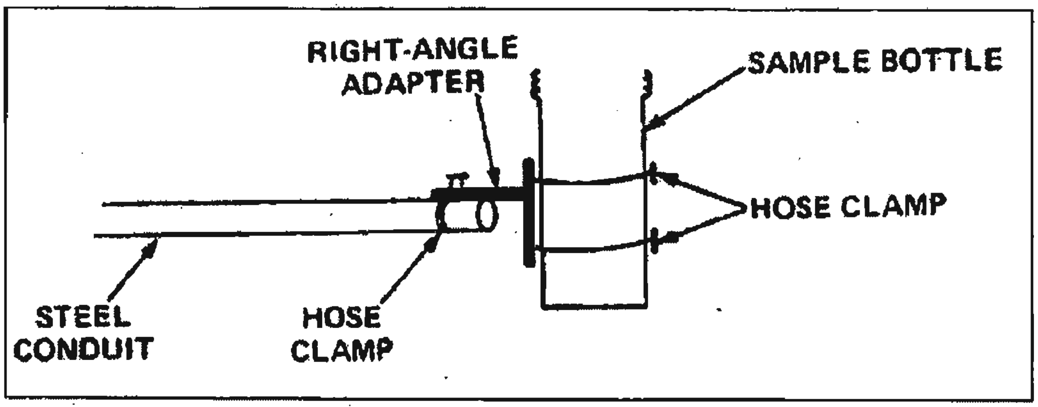
Depth (Ft.)	Lithology Change (Depth/Ft.)	MATERIAL DESCRIPTION Soil/Waste Characteristics (lithology, density, color, etc.)	USCS	Remarks	PID/FID READING Source (ppm)	BZ (ppm)

TEST PIT CROSS SECTION AND / OR PLAN VIEW

REMARKS: ______________

PHOTO LOG: ______________

ATTACHMENT D
REMOTE SAMPLE HOLDER FOR TEST PIT/TRENCH SAMPLING



APPENDIX B

QUALITY ASSURANCE PROJECT PLAN (QAPP)

Rev. 1
06/25/04

QUALITY ASSURANCE PROJECT PLAN

REMEDIAL INVESTIGATION
FOR SITE 4
NAVAL CONSTRUCTION BATTALIAN CENTER GULFPORT
GULFPORT, MISSISSIPPI

Submitted to:
Southern Division
Naval Facilities Engineering Command
2155 Eagle Drive
North Charleston, South Carolina 29406

Submitted by:
Tetra Tech NUS, Inc.
661 Andersen Drive, Foster Plaza 7
Pittsburgh, Pennsylvania 15220

In support of:

"CLEAN" CONTRACT NUMBER N62467-94-D-0888
CONTRACT TASK ORDER 283

June 2004

PREPARED UNDER THE SUPERVISION OF:	APPROVED BY:
	Paul V. Frank
ROBERT FISHER, P.G. TASK ORDER MANAGER TETRA TECH NUS, INC TALLAHASSEE, FLORIDA	PAUL V. FRANK QUALITY ASSURANCE MANAGER TETRA TECH NUS, INC PITTSBURGH, PENNSYLVANIA

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SECTION

Distribution List

A. Conrad, Navy SDIV
P. Weathersby, MSDEQ
G. Crane, NCBC Gulfport
B. Fisher, TtNUS (2 copies)
M. Perry, TtNUS

ACRONYMS/ABBREVIATIONS

AA	Atomic Absorption Spectrophotometer
BFB	Bromofluorobenzene
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-Term Environmental Action, Navy
CLP	Contract Laboratory Program
COC	Contaminant of Concern
C-O-C	Chain of Custody
CTL	Clean-up Target Level
CTO	Contract Task Order
CVAA	Cold Vapor Atomic Absorption
DFTPP	Decafluorotriphenylphosphine
DO	Dissolved Oxygen
DPT	Direct-Push Technology
DQO	Data Quality Objective
EDB	Ethylene Dibromide
EISOPQAM	Environmental Investigations Standard Operation Procedure and Quality Assurance Manual
FOL	Field Operations Leader
FTMR	Field Task Modification Request
GC	Gas Chromatograph
GFAA	Graphite Furnace Atomic Absorption
HASP	Health & Safety Plan
HR	High Resolution
HSM	Health and Safety Manager
ICP	Inductively-Coupled Plasma Atomic-Emission Spectrometer
IDL	Instrument Detection Limit
LCS	Laboratory Control Sample
MCL	Maximum Contamination Level
MDEQ	Mississippi Department of Environmental Quality
MDL	Method Detection Limit
MS	Mass Spectrometer
MS/MSD	Matrix Spike/Matrix Spike Duplicate
NA	Not Applicable
NCBC	Naval Construction Battalion Center
NELAC	National Environmental Laboratory Accreditation Conference
NFESC	Naval Facilities Engineering Service Center
NIST	National Institute of Science and Technology
NTU	Nephelometric Turbidity Unit
ORP	Oxidation-Reduction Potential
PAH	Polynuclear Aromatic Hydrocarbon
PARCC	Precision, Accuracy, Representativeness, Comparability, Completeness
PCB	Polychlorinated Biphenyl
PFK	Perfluorokerosene
PM	Program Manager
PQL	Practical Quantitation Limit
RBC	Risk-Based Concentration
QA	Quality Assurance
QAM	Quality Assurance Manager
QAO	Quality Assurance Officer
QAPP	Quality Assurance Project Plan
QC	Quality Control

ACRONYMS/ABBREVIATIONS (cont.)

RDL	Required Detection Limit
RI	Remedial Investigation
RL	Reporting Limit
RPD	Relative Percent Difference
RQL	Required Quantitation Limit
SDG	Sample Delivery Group
SOP	Standard Operating Procedure
EISOPQAM	Standard Operation Procedure and Quality Assurance Manual
SOW	Statement of Work
SVOC	Semi-Volatile Organic Compound
SW	Solid Waste
TAL	Target Analyte List
TCL	Target Compound List
TOC	Total Organic Carbon
TOM	Task Order Manager
TtNUS	Tetra Tech NUS, Inc.
UMhos/cm	micromhos per centimeter
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound
WP	Work Plan
%R	Percent Recovery
µg/L	microgram per liter
mg/L	milligram per liter
mg/kg	milligram per kilogram
mV	millivolt
ng/kg	nanogram per kilogram
pg/L	picogram per liter

1.0 PROJECT DESCRIPTION

1.1 INTRODUCTION

This Quality Assurance Project Plan (QAPP) has been prepared by Tetra Tech NUS, Inc. (TtNUS) on behalf of the United States Navy Southern Division Naval Facilities Engineering Command and the Naval Construction Battalion Center (NCBC) Gulfport, Gulfport, Mississippi, under the Comprehensive Long-Term Environmental Action Navy (CLEAN III) Contract Number N62467-94-D-0888, Contract Task Order (CTO) 288. The project planning documents for the remedial investigation to be performed at NCBC Gulfport Site 4, located in Gulfport, Mississippi include the QAPP and the following associated documents:

- The United States Environmental Protection Agency (USEPA) Region IV Environmental Investigations Standard Operating Procedures and Quality Assurance Manual (EISOPQAM)

- The Remedial Investigation (RI) Workplan (WP), prepared by TtNUS, dated October 2003

- The Health and Safety Plan (HASP)

This QAPP presents the organization, objectives, planned activities, and specific Quality Assurance/Quality Control (QA/QC) procedures associated with the sampling program. Specific protocols for sample collection, sample handling and storage, chain-of-custody, and laboratory and field analyses are described within this document. The QA/QC procedures for this project are structured in accordance with applicable technical standards, the Naval Facilities Engineering Service Center (NFESC) guidance document "Navy Installation Restoration Chemical Data Quality Manual" (September 1999), and USEPA Region IV and MDEQ requirements, regulations, guidance, and technical standards.

1.2 FACILITY DESCRIPTION

A description of NCBC Gulfport, including its location, size and borders, site conditions, natural and man-made features, and zones of investigation, is provided in Section 2.0 of the WP.

1.3 SITE HISTORY

The site history, including historical and background information, is provided in Section 2.0 of the WP.

1.4 PROJECT OBJECTIVES

This section discusses the overall project objectives, the anticipated target parameters, and intended data uses for both field and laboratory analytical data.

1.4.1 Overall Project Objectives

The RI field investigation at Site 4 is being conducted to provide sufficient data to:

- Fully characterize the nature and extent of contamination at Site 4.
- Develop a baseline risk assessment to determine if a remedial response is required.
- Evaluate remedial response objectives with respect to the contaminants of concern, the areas and volumes of contaminated media, and existing and potential exposure routes and receptors of concern as part of the feasibility study.

In order to achieve these objectives, samples from soil (surface and subsurface) surface water, sediment, seeps, and groundwater will be collected and analyzed to determine the nature and extent of contamination at Site 4. Previous investigations at the site focused on potential herbicide orange disposal at the site and the related dioxin contamination; therefore additional samples will be collected and analyzed to evaluate the nature and extent of other contaminants that may have been released at the site. Analytical results from the various media sampled will also be used to confirm the extent of a vinyl chloride plume detected during previous investigations and to evaluate the potential for natural attenuation of the vinyl chloride plume as a remedial option. Project objectives are discussed in more detail in Section 4.0 of the WP.

1.4.2 Project Target Parameters and Intended Data Uses

This section discusses the field and laboratory analytical information to be generated during the course of the investigation. Field parameters and intended data uses are discussed in Section 1.4.2.1. Laboratory parameters and intended data uses are discussed in Section 1.4.2.2.

1.4.2.1 Field Parameters

Field parameters will include those parameters associated with groundwater and soil sampling and analysis. Field measurements will be completed using simple field instrumentation.

The following field parameters will be measured during the course of groundwater sampling:

- specific conductance,
- pH,
- turbidity,
- temperature,
- oxidation-reduction potential (ORP), and
- Salinity

Specific conductance, pH, turbidity and temperature will be used to determine the progress of well purging prior to groundwater sample collection. Specific conductance and pH will also be used as general indicators of water quality. Specific conductance, pH, turbidity, temperature and ORP will be measured using field water-quality meters. Further details regarding field-sampling methods are provided in Section 16 of the USEPA EISOPQAM.

The following field parameter will be measured during the course of soil sampling:

- soil headspace organic vapor concentration

The soil headspace organic vapor concentration will be used for selection of soil samples submitted for off site laboratory analysis. The soil headspace organic vapor concentration will be measured using a portable flame-ionization detector (FID) or photo-ionization detector (PID) organic vapor analyzer. Further details regarding field-sampling methods are provided in Section 16 of the USEPA EISOPQAM.

1.4.2.2 Laboratory Parameters

The analytical methods to be used for the Site 4 groundwater, surface water, soil, and sediment samples have been selected based on data from previous investigations at NCBC Gulfport. The analytical data will be used to fully characterize the nature and extent of the contamination at Site 4. The suite of analyses for the Site 4 investigation is listed in Table 1-1.

TABLE 1-1

ANALYTICAL METHODS AND SAMPLING SUMMARY
ALL MEDIA
NCBC GULFPORT SITE 4

Parameter	Method (aqueous/soil)	No. Soil	No. Aqueous
TAL Metals +CN	SW-846 6010B/7000A/9012	27	47
TCL VOCs	SW-846 8260B	27	71
TCL SVOCs	SW-846 8270D	27	47
TCL Pesticides	SW-846 8081B	27	47
TCL PCBs	SW-846 8082A	27	47
Chlorinated Herbicides	SW-846 8151A	27	47
Organophosphorous Pesticides	SW-846-8141A	0	36
Dioxin/Furans	SW-846 8290A	13	16
Anions (nitrite, nitrate, sulfate, sulfide, chloride)	EPA 300.0	0	28
Dissolved Gasses (methane, ethane, ethene)	SW-846 3810 or RSK SOP 147 and 175	0	28
TOC	SW-846 9060	26	28
Dissolved hydrogen	Bubble strip method	0	28
Grain size and moisture content	ASTM D 421/422	3	0
Atterberg Limits	ASTM D 4318	3	0

Tables 1-2 through 1-8 provide a summary of the target compounds, analytes, and associated Required Quantitation Limits/ Required Detection Limits (RQLs/RDLs). The RQLs listed in the tables meet the required Maximum Contamination Limits (MCLs) as provided in the USEPA Drinking Water Regulations and Health Advisories, October 1996. If an MCL is not available for a given analyte, then the USEPA Region III Risk-Based Concentrations (RBCs) are used for comparison. Analytical methods are further discussed in Section 8.0 of this QAPP.

TABLE 1-2

SW-846 8260B ANALYTICAL QUANTITATION LIMITS
TCL* VOCs
NCBC GULFPORT SITE 4

Page 1 of 2

Parameter	Required Quantitation Limit	
	Solid Samples	Aqueous Samples
Volatile Organic Compounds	**µg/kg**	**µg/L**
Acetone	10	5
Benzene	10	1
Bromodichloromethane	10	1
Bromoform	10	1
Bromomethane	10	1
2-Butanone	10	5
Carbon disulfide	10	1
Carbon tetrachloride	10	1
Chlorobenzene	10	1
Chloroethane	10	1
Chloroform	10	1
Chloromethane	10	1
Dibromochloromethane	10	1
1,2-Dibromo-3-chloropropane	NA	1
1,2-Dibromoethane	10	1
1,2-Dichlorobenzene	NA	1
1,3-Dichlorobenzene	NA	1
1,4-Dichlorobenzene	NA	1
1,1-Dichloroethane	10	1
1,2-Dichloroethane	10	1
1,1-Dichloroethene	10	1
cis-1,2-Dichloroethene	NA	1
1,1,2-Trichloro –1,2,2-trifluoroethane	10	1
MethylAcetate	10	1
Methyl tert-butylether	10	1
Bromochloromethane	10	1
Cyclohexane	10	1
1,2-Dichloropropane	10	1
Methylcyclohexane	10	1
Isopropylbenzene	10	1
1,2,3-Trichlorobenzene	10	1
1,2,4-Trichlorobenzene	10	1

TABLE 1-2

SW-846 8260B ANALYTICAL QUANTITATION LIMITS
TCL* VOCs

NCBC GULFPORT SITE 4

Page 2 of 2

Parameter	Required Quantitation Limit	
	Solid Samples	**Aqueous Samples**
Volatile Organic Compounds	**µg/kg**	**µg/L**
1,2-Dichloroethene (total)	10	NA
cis-1,3-Dichloropropene	10	1
trans-1,3-Dichloropropene	10	1
Ethylbenzene	10	1
2-Hexanone	10	5
4-Methyl-2-pentanone	10	5
Methylene chloride	10	2
Styrene	10	1
1,1,2,2-Tetrachloroethane	10	1
1,1,1-Trichloroethane	10	1
1,1,2-Trichloroethane	10	1
Trichloroethene	10	1
Tetrachloroethene	10	1
Toluene	10	1
Vinyl chloride	10	1
Xylenes (total)	10	1
Trichlorofluoromethane	NA	5
Dichlorodifluoromethane	NA	1

*Target Compound List from the Contract Laboratory Program, Organic Analytical Statement of Work (OLM04.2, USEPA)

TABLE 1-3
SW-846 8270D ANALYTICAL QUANTITATION LIMITS
TCL* SVOCs

NCBC GULFPORT SITE 4

PAGE 1 OF 3

Parameter	Required Quantitation Limit	
	Solid Samples	Aqueous Samples
Semivolatile Organic Compounds	**µg/kg**	**µg/L**
Acenaphthene	330	10
Acenaphthylene	330	10
Anthracene	330	10
Benzo(a)anthracene	330	10
Benzo(a)pyrene	330	10
Benzo(b)fluoranthene	330	10
Benzo(g,h,i)perylene	330	10
Benzo(k)fluoranthene	330	10
Bis(2-chloroethoxy)methane	330	10
Bis(2-chloroethyl)ether	330	10
Bis(2-ethylhexyl)phthalate	330	5
4-Bromophenyl-phenylether	330	10
Butylbenzylphthalate	330	10
Carbazole	330	NA
4-Chloro-3-methylphenol	330	10
4-Chloroaniline	330	10
2-Chloronaphthalene	330	10
2-Chlorophenol	330	10
4-Chlorophenyl-phenylether	330	10
Chrysene	330	10
Dibenz(a,h)anthracene	330	10
Dibenzofuran	330	10
3,3'-Dichlorobenzidine	330	10
Diethylphthalate	330	10
Di-n-butylphthalate	330	10
Di-n-octylphthalate	330	10
4,6-Dinitro-2-methylphenol	830	25
2,4-Dinitrophenol	830	25
2,4-Dinitrotoluene	330	10
Benzaldehyde	330	10
Caprolactam	330	10
1,1' -Biphenyl	330	10
Atrazine	330	10

TABLE 1-3
SW-846 8270D ANALYTICAL QUANTITATION LIMITS
TCL* SVOCs

NCBC GULFPORT SITE 4

PAGE 2 OF 3

Parameter	Required Quantitation Limit	
	Solid Samples	Aqueous Samples
Semivolatile Organic Compounds	µg/kg	µg/L
1,2,4,5-Tetrachlorobenzene	330	10
Acetaphenone	330	10
2,4-Dimchlorophenol	330	10
Dimethylphthalate	330	10
2,4-Dimethylphenol	330	10
2,6-Dinitrotoluene	330	10
Fluoranthene	330	10
Fluorene	330	10
Hexachlorobenzene	330	10
Hexachlorobutadiene	330	10
Hexachlorocyclopentadiene	330	10
Hexachloroethane	330	10
Indeno(1,2,3-cd)pyrene	330	10
Isophorone	330	10
2-Methylnaphthalene	330	10
2-Methylphenol	330	10
4-Methylphenol	330	10
Naphthalene	330	10
2-Nitroaniline	330	25
3-Nitroaniline	830	25
4-Nitroaniline	830	25
Nitrobenzene	330	10
2-Nitrophenol	330	10
4-Nitrophenol	830	25
N-nitroso-di-n-propylamine	330	10
N-nitrosodiphenylamine	330	10
2,2'-Oxybis(1-chloropropane)	330	10
Pentachlorophenol	830	25
Phenanthrene	330	10

TABLE 1-3
SW-846 8270D ANALYTICAL QUANTITATION LIMITS
TCL* SVOCs

NCBC GULFPORT SITE 4

PAGE 3 OF 3

Parameter	Required Quantitation Limit	
	Solid Samples	Aqueous Samples
Semivolatile Organic Compounds	**µg/kg**	**µg/L**
Phenol	330	10
Pyrene	330	10
2,4,5,-Trichlorophenol	830	25
2,4,6,-Trichlorophenol	330	10

* Target Compound List from the Contract Laboratory Program, Organic Analytical Statement of Work (OLM04.2, USEPA)
NA Not Applicable

TABLE 1-4
SW-846 8081B ANALYTICAL QUANTITATION LIMITS
TCL* PESTICIDES

NCBC GULFPORT SITE 4

Parameter	Required Quantitation Limit	
	Solid Samples	Aqueous Samples
Pesticides	µg/kg	µg/L
Aldrin	1.7	0.05
alpha-Benzene hexachloride (BHC)	1.7	0.05
alpha-Chlordane	1.7	0.05
beta-BHC	1.7	0.1
4,4'-DDE	3.3	0.1
4,4'-DDD	3.3	0.1
4,4'-DDT	3.3	0.1
delta-BHC	1.7	0.05
Dieldrin	3.3	0.1
Endosulfan I	1.7	0.05
Endosulfan II	3.3	0.05
Endosulfan sulfate	3.3	0.1
Endrin	3.3	0.1
Endrin aldehyde	3.3	0.1
Endrin ketone	3.3	NA
gamma-BHC (Lindane)	1.7	0.2
gamma-Chlordane	1.7	0.05
Heptachlor	1.7	0.05
Heptachlor epoxide	1.7	0.1
Methoxychlor	17	0.4
Toxaphene	170	1.0

* Target Compound List from the Contract Laboratory Program, Organic Analytical Statement of Work (OLM04.2, USEPA)

TABLE 1-5
SW-846 8082A ANALYTICAL DETECTION LIMITS
TCL* PCBs

NCBC GULFPORT SITE 4

Parameter	Required Quantitation Limit	
	Solid Samples	Aqueous Samples
PCB's	**µg/kg**	**µg/L**
Aroclor-1016	33	PQL[(2)]
Aroclor-1221	67	PQL
Aroclor-1232	33	PQL
Aroclor-1242	33	PQL
Aroclor-1248	33	PQL
Aroclor-1254	33	PQL
Aroclor-1260	33	PQL

* Target Compound List from the Contract Laboratory Program, Organic Analytical Statement of Work (OLM04.2, USEPA)
(2) PQL Practical Quantitation Limit, determined by the laboratory

TABLE 1-6

SW-846 8151A ANALYTICAL DETECTION LIMITS
APPENDIX IX* CHLORINATED HERBICIDES LIST

NCBC GULFPORT SITE 4

Parameter	Required Quantitation Limit
	Aqueous Samples
Target Compound List	**µg/L**
2,4-Dichlorophenoxyaceticacid[2,4-D]	PQL(2)
Dinoseb	PQL
-[2,4,5-Trichlorophenoxyl] propionic acid[2,4,5-TP][Silvex]	PQL
2, 4, 5-Trichlorophenoxyaceticacid [2,4,5-T]	PQL

* Appendix IX List defined in 40 CFR, Part 264, Appendix IX Groundwater Monitoring List
(2) PQL Practical Quantitation Limit, determined by the laboratory

TABLE 1-7
SW-846 8290A ANALYTICAL DETECTION LIMITS
DIOXIN/FURAN LIST

NCBC GULFPORT SITE 4

Parameter	Required Quantitation Limit	
	Solid Samples	Aqueous Samples
Dioxins/Furans	**Ng/kg**	**Pg/L**
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	1.0	0.01
1,2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDD)	1.0	0.01
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	2.5	0.025
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	2.5	0.025
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (HxCDD)	2.5	0.025
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HPCDD)	2.5	0.025
1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin (OCDD)	5.0	0.05
2,3,7,8-Tetrachlorodibenzofuran (TCDF)	1.0	0.01
1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)	1.0	0.01
2,3,4,7,8-Pentachlorodibenzofuran (PeCDF)	1.0	0.01
1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDF)	2.5	0.025
1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)	2.5	0.025
1,2,3,7,8,9-Hexachlorodibenzofuran (HxCDF)	2.5	0.025

TABLE 1-7
SW-846 8290 ANALYTICAL DETECTION LIMITS

DIOXIN/FURAN LIST

NCBC GULFPORT SITE 4

PAGE 2 OF 2

Parameter	Required Quantitation Limit	
	Solid Samples	Aqueous Samples
Dioxins/Furans	**Ng/kg**	**Ng/L**
2,3,4,6,7,8-Hexachlorodibenzofuran (HxCDF)	2.5	0.025
1,2,3,4,6,7,8-Heptachlorodibenzofuran (HpCDF)	2.5	0.025
1,2,3,4,7,8,9-Heptachlorodibenzofuran (HpCDF)	2.5	0.025
1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF)	5.0	0.05

TABLE 1-8
SW-846 6010B and 9012 ANALYTICAL DETECTION LIMITS
TAL INORGANICS and CYANIDE

NCBC GULFPORT SITE 4

Parameter	Required Detection Limit	
	Soil Samples	Aqueous Samples
Inorganics	**µg /kg**	**µg/L**
Aluminum	IDL	IDL
Antimony	IDL	IDL
Arsenic	IDL	IDL
Barium	IDL	IDL
Beryllium	IDL	IDL
Cadmium	IDL	IDL
Calcium	IDL	IDL
Chromium (total)	IDL	IDL
Cobalt	IDL	IDL
Copper	IDL	IDL
Iron	IDL	IDL
Lead	IDL	IDL
Magnesium	IDL	IDL
Manganese	IDL	IDL
Mercury	IDL	IDL
Nickel	IDL	IDL
Potassium	IDL	IDL
Selenium	IDL	IDL
Silver	IDL	IDL
Sodium	IDL	IDL
Thallium	IDL	IDL
Vanadium	IDL	IDL
Zinc	IDL	IDL
Cyanide	IDL	IDL

Detection Limit for soil adjusted for the amount of sample analyzed and percent moisture.
IDL Instrument Detection Limit

TABLE 1-9

SW-846 8141A ANALYTICAL QUANTITATION LIMITS APPENDIX IX* ORGANOPHOSPHOROUS PESTICIDES

NCBC GULFPORT SITE 4

Parameter	Required Quantitation Limit
	Aqueous Samples
Organophosphorouos Pesticides	**µg/L**
Dimethoate	PQL(2)
Disulfoton	PQL
Famphur	PQL
Parathion	PQL
Methyl-Parathion	PQL
Ethyl-Parathion	PQL
Phorate	PQL
Sulfotepp	PQL
Thionazin	PQL

* Appendix IX List defined in 40 CFR, Part 264, Appendix IX Groundwater Monitoring List
(2) PQL Practical Quantitation Limit, determined by the laboratory

1.5 Sample Network Design and Rationale

The sample network design and rationale is discussed in Section 5.0 of the WP. Figures displaying all proposed sampling locations are provided in Section 5.0 of the WP.

1.6 Project Schedule

The project schedule is discussed **Section 10.0** of the WP.

2.0 PROJECT ORGANIZATION

The overall organization of the Site 4 remedial investigation is outlined in Figure 2-1. The various quality assurance and management responsibilities of key TtNUS project personnel are defined in the following paragraphs.

CLEAN Program Manager - The TtNUS Program Manager is Debbie Wroblewski she is responsible for the execution of all contractual obligations. She serves as the primary Program point of contact for the client and provides an interface between the Navy and the project staff.

CLEAN Task Order Manager - The Task Order Manager (TOM) is Robert Fisher he is responsible for project performance, budget, and schedule, and for ensuring the availability of necessary personnel, equipment, subcontractors, and services. He will direct the development of the field program, evaluation of findings, determination of conclusions and recommendations, and preparation of technical reports.

Field Operations Leader/Sampling Coordinator – The TtNUS Field Operations Leader (FOL) is responsible for providing onsite supervision of day-to-day activities on the project. The FOL serves as the primary onsite contact with the client and subcontractors. The FOL is also responsible for all field QA/QC and safety-related issues as defined in the Health and Safety Plan. In addition, the FOL will coordinate the schedule of field sampling activities with the schedule and capacity requirements of the selected analytical laboratories. All sampling will be coordinated to assure that environmental sampling is conducted in a manner that complies with all QA/QC requirements and is in compliance with holding time and analytical procedure requirements. The TtNUS FOL for CTO No. 283 is Bill Olsen.

Health and Safety Manager - The Program Health and Safety Manager (HSM) will review and internally approve the Health and Safety Plan tailored to the specific needs of the investigation. In consultation with the TOM and FOL, the HSM will ensure that an adequate level of personal protection exists for anticipated potential hazards for all field personnel. As the HSM does not report to either the Program or Task Order Manager, his actions are not dictated by Program or project constraints (such as budget and schedule) other than the assurance of appropriate safeguards while conducting investigation activities. The TtNUS HSM is Mr. Matthew Soltis, CIH.

Quality Assurance Manager - The TtNUS Quality Assurance Manager (QAM) for this study is Mr. Paul Frank. The QAM operates independently of the TOM and is responsible for all Program-wide, quality assurance issues and the development of the Quality Assurance Project Plan (QAPP). The QAM appoints a project Quality Assurance Officer (QAO) for the project. The specific responsibilities of the QAO include reviewing laboratory reports to ensure that all the QA/QC requirements have been met, and inspecting work activities and project deliverables to make sure that QC activities are not compromised. The QAO will communicate issues of non-compliance directly to the TOM and the QAM. The TtNUS QAO for CTO No. 288 is Mr. W. Howard Engle.

Project Laboratories – The laboratory will be subcontracted by TtNUS to perform the routine chemical analyses for the environmental samples collected for the corrective measures implementation program. The laboratory is responsible for checking laboratory quality against the requirements of the QAPP before the laboratory reports are transferred to TtNUS.

FIGURE 2-1

**PROJECT ORGANIZATION
NCBC GULFPORT, GULFPORT, MISSISSIPPI**

NAVY Remedial Project Manager (RPM)	**MSDEQ Project Manager (PM)**
Art Conrad	Phillip Weathersby/Bob Merrill

Base Project Manager

Gordon Crane

Tetra Tech NUS Program Management

Mr. Robert Fisher - Project Manager
Mr. Matt Soltis - Health & Safety Manager
Mr. Paul Frank - Quality Assurance Manager

Tetra Tech NUS Technical Staff

Chemistry
Geology/Hydrology
Health & Safety
Permitting
Field Samplers
Word Processing

Subcontractors

Analytical Laboratories
Direct-Push Technology Drillers
Survey Contractor

3.0 QUALITY ASSURANCE OBJECTIVES FOR MEASUREMENT DATA

The overall QA objective for this RI is to develop and implement procedures for field sampling, chain-of-custody, laboratory analysis, and data reporting that will provide valid and relevant data to support the RI decision process. Intended data uses are described in Section 1.4.2 of this QAPP. Specific procedures for sampling, chain-of-custody, laboratory instrument calibration, laboratory analysis, reporting of data, internal quality control, audits, preventive maintenance of field and laboratory equipment, and corrective action are described in other sections of this QAPP.

The PARCC parameters (precision, accuracy, representativeness, comparability, and completeness) are qualitative and/or quantitative statements regarding the quality characteristics of the data used to support project objectives and ultimately, environmental decisions. These parameters are discussed in the remainder of this section. Specific routine procedures used to assess the quantitative parameters (precision, accuracy, and completeness) are provided in Section 12.0.

3.1 PRECISION

Precision is a measure of the amount of variability and bias inherent in a data set. Precision describes the reproducibility of measurements of the same parameter for samples under similar conditions. The equation for determining precision is provided in Section 12.2.

3.1.1 Field Precision Objectives

Duplicate field measurements for aqueous matrix samples will not be required. In lieu of using matrix spikes and using independent QC check standards, more frequent continuing calibrations will be performed. Field measurement meters will be calibrated immediately before the initial analysis and every four hours after the initial calibration, while sampling.

3.1.2 Laboratory Precision Objectives

Laboratory precision QC samples are analyzed at a frequency of 5 percent (i.e., one quality control sample per 20 environmental samples). Laboratory precision is measured via comparison of calculated Relative Percent Difference (RPD) values and precision control limits specified in the analytical method or by the laboratory's QA/QC Program.

Precision for organic analyses will be measured via the RPDs for matrix spike/matrix spike duplicate (MS/MSD) samples. The analytical method for low-concentration volatile analysis does not require a specific QC sample to monitor precision, although the calibration requirements of the method (i.e., specific limits of precision for the calibration standards) do ensure that a sufficient level of precision is achieved. (Calibration is further discussed in Section 7.0.).

Precision for metals analyses will be measured via the RPDs for duplicate sample analyses.

Precision for the remaining miscellaneous parameters will typically be measured via the RPD results for laboratory duplicate samples. Internal laboratory control limits for precision, which are typically set at three times the standard deviation of a series of RPDs, will be used for evaluation of precision for these parameters.

3.2 ACCURACY

Accuracy is the degree of agreement between the observed value and an accepted reference value. The equation for determining accuracy is provided in Section 12.1.

3.2.1 Field Accuracy Objectives

The determination of accuracy in the field is not required. In lieu of using matrix spikes and using independent QC check standards, more frequent continuing calibrations will be performed. Field measurement meters will be calibrated immediately before the initial analysis and every four hours after the initial calibration, while sampling.

3.2.2 Laboratory Accuracy Objectives

Accuracy in the laboratory is measured through the comparison of a spiked sample result against a known or calculated value expressed as a percent recovery (%R). Percent recoveries are derived from the analysis of known amounts of compounds spiked into deionized water [i.e., laboratory control sample (LCS) analysis], or into actual samples (i.e., surrogate or MS analysis). LCS analyses measure the accuracy of laboratory operations. Surrogate and MS analyses also measure the accuracy of laboratory operations, but as affected by the sample matrix. LCS and/or MS analyses are performed with a frequency of one per twenty associated samples of like matrix. Surrogate spike analysis is performed for all chromatographic organic analyses. Laboratory accuracy is assessed via comparison of calculated Percent Recoveries (%Rs) with accuracy control limits specified in the analytical method or by the laboratory's QA/QC Program.

Accuracy for inorganic (metals) analyses will be measured via the %R for LCS and MS analyses.

Accuracy for the remaining parameters will typically be measured via %Rs for MSs and/or LCSs. Internal laboratory control limits for accuracy, which are typically set at three times the standard deviation of a series of %R values, will be used for evaluation of accuracy for these parameters.

3.3 COMPLETENESS

Completeness is a measure of the amount of usable, valid analytical data obtained, compared to the amount expected. Completeness is typically expressed as a percentage. The equation for completeness is presented in Section 12.3.

The ideal objective for completeness is 100 percent (i.e., every sample planned to be collected is collected; every sample submitted for analysis yields valid data). However, samples can be rendered unusable during shipping or preparation (e.g., bottles broken or extracts accidentally destroyed), errors can be introduced during analysis (e.g., loss of instrument sensitivity, introduction of ambient laboratory contamination), or strong matrix effects can skew analytical results (e.g., extremely low matrix spike recovery).

These instances may result in data that do not meet QC criteria. Based on these considerations, 95 percent is considered an acceptable target for the data completeness objective. If critical data points are lost, resampling and/or reanalysis might be required.

As further discussed in Section 11.2.2, one hundred percent of the laboratory data for the NCBC Gulfport Site 4 investigation program will undergo a full validation review. A full data validation review is defined in Section 11.2.2. Data rejected as a result of the review process will be treated as unusable data unless additional review shows that the data are usable.

3.4 REPRESENTATIVENESS

Representativeness is an expression of the degree to which the data accurately and precisely depict the actual characteristics of a population or environmental condition existing at an individual sampling point. Use of standardized sampling, handling, analytical, and reporting procedures ensures that the final data accurately represent actual site conditions.

3.4.1 Measures to Ensure Representativeness of Field Data

Representativeness depends on the proper design of the sampling program. It will be satisfied by ensuring that the WP is followed and that proper sampling techniques are used. The sampling network for the NCBC Gulfport Site 4 sampling program was designed to provide data representative of site conditions. During development of this network, consideration was given to the baseline condition determined from prior sampling and analytical data. The rationale of the sampling network is discussed in detail in Section 3.0 of the WP.

3.4.2 Measures to Ensure Representativeness of Laboratory Data

Representativeness in the laboratory data is ensured by using the proper analytical procedures, meeting sample-holding times, and analyzing and assessing duplicate samples.

3.5 COMPARABILITY

Comparability is defined as the confidence with which one data set can be compared to another (e.g., between sampling points; between sampling events). Comparability is achieved by using standardized sampling and analysis methods, and data reporting formats (including use of consistent units of measure). Additionally, consideration is given to seasonal conditions and other environmental variations that could influence data results.

3.5.1 Measures to Ensure Comparability of Field Data

Comparability is dependent upon the proper design of the sampling program and will be satisfied by ensuring that the WP is followed. It also depends on recording field measurements using the correct units.

3.5.2 Measures to Ensure Comparability of Laboratory Data

Planned analytical data will be comparable when similar sampling and analytical methods are used and documented. Results will be reported in units that ensure comparability with previous data and with current State and Federal standards and guidelines.

3.6 LEVEL OF QUALITY CONTROL EFFORT

Trip blank, rinsate blank, method blank, field and laboratory duplicate, laboratory control, and matrix spike samples will be analyzed to assess the quality of the data resulting from the field sampling and analytical programs.

External QC measures (i.e., field quality control samples) consist of field duplicates, trip blanks, and equipment rinsate blanks. Information gained from these analyses further characterizes the level of data quality obtained to support project goals. Each of these types of field quality control samples undergoes the same preservation, analysis, and reporting procedures as the related environmental samples. Each type of field quality control sample is discussed below.

Field duplicates are two samples collected independently at a sampling location (e.g., surface water). Field duplicates are collected and analyzed by the laboratory for all chemical constituents to measure the precision of the sampling and analysis methods employed. The level of the QC effort will be one field duplicate for every 5 to 9 samples and then 10% of the number of additional investigative samples.

Trip blanks, consisting of analyte-free water, will be submitted to the laboratory to provide the means to assess the quality of the data resulting from the field-sampling program. Trip blanks only pertain to samples collected for VOC analysis. Trip blanks are used to assess the potential for contamination of samples to be analyzed for VOCs by contaminant migration into sample containers during sample shipment and storage. Trip blanks are prepared by the laboratory prior to the sampling event, shipped to the site with the sample containers, and kept with the investigative samples throughout the sampling event. They are then packaged for shipment with other VOC samples and sent for analysis. There will be one trip blank included in each sample-shipping container that contains samples for VOC analysis. At no time after preparation will the sample containers for the trip blanks be opened before they reach the laboratory. Trip blanks are further discussed in Sections 5.2 and 5.13.10 of the EISOPQAM.

Equipment rinsate blanks are obtained under representative field conditions by collecting the rinse water generated by running analyte-free water through sample collection equipment after decontamination and prior to use. At least one equipment blank will be collected per day, per matrix. If pre-cleaned, dedicated, or disposable sampling equipment is used, one rinsate blank per type of equipment used must be collected as a "batch blank." Rinsate blanks are analyzed by the laboratory for the same chemical constituents as the associated environmental samples. Equipment blanks are further discussed in Section 5.2 and 5.13.10 of the EISOPQAM.

Method blank samples are generated within the laboratory and used to assess contamination resulting from laboratory procedures. Samples with positive results corresponding to positive results in the method blank will be designated with a qualifier by the laboratory. Method blanks are further discussed in Section 10.2 of this QAPP.

MS/MSD samples are investigative samples spiked with known quantities of target analytes. MS/MSDs provide information about the effect of the sample matrix on the measurement methodology. One MS/MSD sample will be collected/designated for every 20 or fewer investigative samples per sample matrix.

The level of QC effort for analytical testing will conform to the appropriate analytical methods, as specified in Table 8-1.

4.0 DATA QUALITY OBJECTIVES

The Data Quality Objective (DQO) Process is a planning approach used to determine the appropriate environmental data collection activities for a specific project. The Data Quality Objectives (DQOs), generated during this process establish the data collection design for the project and define:

- The purpose of the data collection
- Where and when to collect samples or measurements
- Which analyses to run
- The requirements for the quality of the data
- How to collect the samples or measurements.

Satisfying the DQOs will result in a data collection design that meets all performance criteria and any other requirements. The DQO Process has been conducted, by all involved parties, on an informal basis throughout the investigation of Site 4.

4.1 PROJECT OBJECTIVE

The primary objective of the RI is to provide suitable data in order to support the preparation of a remedy for contamination at Site 4 that is protective of human health ecological health and the environment. In order to achieve this primary objective, samples from various media will be collected and analyzed to fill data gaps from previous investigations. Previous investigations at the site focused on dioxin-related contaminants; therefore samples will be collected and analyzed to evaluate the nature and extent of other contaminants that may have been released at the site, including chlorinated solvent-related contamination previously documented at the site.

4.2 SELECTION OF MEDIA

Based on the Site Conceptual Model (Figure 3-1, Workplan) The media selected for investigation include those identified as potential contaminant sources and migration pathways. Subsurface soil, surface water, sediment, groundwater, surface soil and water samples from seeps will be collected to fully define the nature and extent of the contamination at Site 4.

4.2.1 Subsurface Soil Data

Soil samples will be collected from locations in the landfill area determined following the geophysical investigation. Subsurface soil will be sampled and screened continuously from the ground surface to a depth of approximately forty feet. This data will detail the distribution of contaminants and the lithology of the subsurface soil at Site 4. The subsurface soil sample data will be compared to groundwater sample data to determine if contaminants in the subsurface soil are present in site groundwater.

4.2.2 Sediment/Surface Water Data

Sediment and surface water samples will be collected from Canal No. 1. The data from the sediment samples will be used to determine if contamination from the landfill area is being transported from the site by sediment movement within the ditch. Samples will be collected from locations in Canal No. 1 upstream and downstream of the landfill.

Surface water sample data will be compared to sediment sample data to determine if sediment contaminants are present in surface water in the ditch and to groundwater sample data to determine if groundwater contaminants are present in surface water in the ditch.

The data from the surface water and sediment samples will also provide information that can be used to determine if human health risk is an immediate concern.

4.2.3 Groundwater Data

Groundwater samples will be collected using DPT methods following the geophysical investigation. DPT groundwater sample locations will be located in the landfill area and in the area of the chlorinated solvent plume previously detected at the site. Following the DPT investigation, groundwater samples will be collected from new and existing monitoring wells located throughout Site 4. Groundwater sample data will be compared to subsurface soil and surface water data to determine if contaminants in the subsurface soil are present in site groundwater or if groundwater contaminants are present in the surface water in Canal No. 1.

4.2.4 Seep Data

Groundwater and surface soil samples will be collected from seeps located on the banks of Canal No. 1 if site conditions permit. The groundwater seep and surface soil data will be compared to surface water and sediment data to determine if contaminants in the groundwater are discharging into Canal No. 1.

4.3 SELECTION OF ANALYSES

The laboratory analytical parameters selected for the RI were chosen based on the potential for release of materials due to past landfill operations at Site 4. A wide range of materials have been used and disposed of at NCBC Gulfport, therefore it was determined that a “full analytical suite” be conducted on the environmental samples. The samples collected at Site 4 will be analyzed for the following:

- TCL VOCs,
- TCL SVOCs,
- TCL Pesticides/PCBs,
- TAL Metals and Cyanide,
- Chlorinated Herbicides,
- Dioxins/Furans, and
- Organophosphorous Pesticides

Selected groundwater samples will also be analyzed for Organophosphorous Pesticides. Based on previous investigations and knowledge of past disposal practices at NCBC Gulfport, the selected analyses should provide a suitable assessment of the nature of the contamination at Site 4.

To aid in evaluating the fate and transport of contaminants in site soil, the soil samples collected for the RI will be analyzed for the following geotechnical and geochemical Parameters:

- TOC
- Grain size + moisture
- Atterberg limits

To evaluate the potential for natural attenuation of organic solvents in groundwater, the following parameters will be analyzed:

- TOC
- Anions
- Dissolved gasses (methane, ethane, ethene)
- Dissolved hydrogen

4.4 DATA QUALITY ASSESSMENT

Data quality is discussed in Sections 11.0 and 12.0 of this QAPP. These sections specifically address data reduction, validation, reporting, precision, accuracy, completeness, and usability.

4.5 SAMPLING AND MEASUREMENT PROCEDURES

Sampling and measurement procedures are specifically discussed in Section 5.0 of this QAPP.

5.0 SAMPLING PROCEDURES

The specific types of field sampling for the NCBC Gulfport Site 4 sampling program are discussed in the WP and will follow the EISOPQAM. In addition, the EISOPQAM and the WP addresses the following field investigation tasks:

- Groundwater-level measurements - Section 15.8, EISOPQAM; Section 5.9, RI WP
- Monitoring well purging - Section 7.2, EISOPQAM
- Sample containers, preservatives, and volume requirements – Appendix A, EISOPQAM
- Field measurements – Section 16, EISOPQAM
- Decontamination procedures – Appendix B, EISOPQAM; Section 5.7, RI WP
- Investigation derived waste – Section 5.15, EISOPQAM; Section 5.11 RI WP
- Sample identification system - Section 5, Subsection 5.3.2 TtNUS CompQAP
- Sample packaging and shipping procedures – Appendix D, EISOPQAM
- Recordkeeping – TtNUS Corporate SOP SA-6.3 (Appendix B)

6.0 CUSTODY PROCEDURES

Sample custody is one of several factors which impact the admissibility of environmental data as evidence in a court of law. Custody procedures help to satisfy the two major requirements for admissibility; relevance and authenticity.

Sample custody is addressed in three parts: field sample collection, laboratory analysis, and final evidence files. Final evidence files, including all originals of laboratory reports and purge files, are maintained under document control in a secure area. An environmental sample or evidence file is considered under custody if:

- the item is in the actual physical possession of an authorized person, or;
- the item is in view of the person after being in his or her possession, or;
- the item was placed in a secure area to prevent tampering; or
- the item is in a designated and identified secure area with access restricted to authorized personnel only.

The chain-of-custody (C-O-C) report is a multi-part, standardized form used to summarize and document pertinent sample information, such as sample identification and type, matrix, date and time of collection, preservation, and requested analyses. Furthermore, through the sequential signatures of various sample custodians (e.g., sampler, air bill number, laboratory sample custodian); the C-O-C report documents sample custody and tracking. A "Cradle-to-Grave" sample tracking will be employed. Custody procedures apply to all environmental and associated field quality control samples obtained as part of the data collection system.

6.1 FIELD CUSTODY PROCEDURES

The Field Operations Leader (FOL; or designee) is responsible for the care and custody of the samples from the time of collection until the samples are relinquished to the analyzing laboratory or entrusted to a commercial courier for transport to the laboratory. C-O-C reports are completed for each sample shipment. The reports are filled out in a legible manner, using waterproof ink, and are signed and dated by the sampler. Pertinent notes, such as whether the sample was field filtered, or whether the sample is suspected to be high in contaminant concentration, are also indicated on the C-O-C report. Information similar to that contained in the C-O-C report is also provided on the sample label, which is securely attached to the sample bottle. C-O-C report forms and sample labels will be supplied by the laboratory subcontractor. In accordance with NFESC guidelines, samples for chemical constituent analysis must be sent (for next-day receipt) to the laboratory within 24-hours of collection.

Full details regarding sample C-O-Cs (including use of custody seals and sample shipment protocols) are contained in TtNUS Corporate Standard Operating Procedure (SOP) SA-6.1, which is provided as Appendix A. TtNUS Corporate SOP SA-6.3, also provided as Appendix B, discusses maintenance of site logbooks, site notebooks, and other field records. All sample records are eventually docketed into the TtNUS project central file.

6.2 LABORATORY CUSTODY PROCEDURES

When samples are received by the laboratory subcontractor, the laboratory's sample custodian examines each cooler's custody seals to verify that they are intact and that the integrity of the environmental samples has been maintained. The sample custodian then signs the C-O-C report. The custodian then opens the cooler and measures its internal temperature. The temperature reading is noted on the accompanying C-O-C report. The sample custodian then examines the contents of the cooler. Sample container breakages or discrepancies between the C-O-C report and sample label documentation are recorded. With the exception of samples for volatile analysis, the pH of chemically preserved samples is checked using pH paper and recorded. All problems or discrepancies noted during this process are to be promptly reported to the TtNUS TOM (or designee). Inter-laboratory C-O-C procedures and specific procedures for sample handling, storage, disbursement for analysis, and remnant disposal will be followed as specified by the subcontract laboratory's SOPs and/or QA Plan.

The laboratory will maintain a hardcopy file of all analytical data associated with this project in a secure area. Access to the data will be limited to laboratory, TtNUS, and Navy personnel. The hardcopy files will be maintained by the laboratory for a minimum of seven years.

6.3 FINAL EVIDENCE FILES

The TtNUS central file will be the repository for all documents, which constitute evidence relevant to sampling and analysis activities as described in this QAPP. TtNUS is the custodian of the evidence file and maintains the contents of these files, including all relevant records, reports, logs, field notebooks, photographs, subcontractor reports and data reviews in a secure, limited access location and under custody of the TtNUS facility manager. The control file will include at a minimum:

- field logbooks
- field data and data deliverables
- photographs
- drawings
- soil boring logs
- laboratory data deliverables

- data validation reports
- data assessment reports
- progress reports, QA reports, interim project reports, etc.
- all custody documentation (chain-of-custody forms, air bills, etc.)

Upon completion of the contract, all pertinent files will be relinquished to the custody of the United States Navy.

7.0 CALIBRATION PROCEDURES AND FREQUENCY

Instrumentation used to perform chemical measurements must be properly calibrated prior to use in order to obtain valid and usable results. The requirement to properly calibrate instruments prior to use applies equally to field instruments as it does to fixed laboratory instruments. Field instrument calibration is discussed in Section 7.1. Laboratory instrument calibration is discussed in Section 7.2.

7.1 FIELD INSTRUMENT CALIBRATION

Field instrument calibration will be conducted according to Section 16 of the USEPA EISOPQAM.

7.2 LABORATORY INSTRUMENT CALIBRATION

Calibration procedures for a specific laboratory instrument will consist of initial calibration (typically 3 to 5 calibration points) and continuing calibration verification. In all cases, the initial calibration will be verified using an independently prepared calibration verification solution. The frequency of calibration will be performed according to the requirements of the specific methods.

All standards used to calibrate analytical instruments must be obtained from the National Institute of Standards and Technology (NIST) or through a reliable commercial supplier with a proven record for quality standards. All commercially supplied standards must be traceable to NIST reference standards where possible and appropriate documentation will be obtained from the supplier. In cases where documentation is not available, the laboratory will analyze the standard and compare the results to an USEPA-supplied known or previous NIST-traceable standard.

The calibration procedures and frequencies used by the subcontract laboratory will comply with the applicable analytical method. Brief descriptions of calibration procedures for major instrument types follow.

7.2.1 <u>GC/MS Volatile Organic Compound Analyses</u>

For volatile organic compounds, the gas chromatograph/mass spectrometer (GC/MS) system will be tuned and calibrated in accordance with the appropriate analytical method. A bromofluorobenzene (BFB) instrument performance check (tuning check) must be run prior to the initial calibration and each continuing calibration and must meet all method-specified criteria before analysis may continue. Initial calibration is required before any samples are analyzed and must include a blank and a minimum of five different concentrations as specified in the method. A BFB tuning check and a continuing calibration check, including the mid-range standard and a blank, must be performed at the beginning of each 12-hour period during which analyses are performed.

7.2.2 GC/MS Semi-Volatile Organic Compound Analyses

For semi-volatile organic compounds, the gas chromatograph/mass spectrometer (GC/MS) system will be tuned and calibrated in accordance with the appropriate analytical method. A decafluorotriphenylphosphine (DFTPP) instrument performance check (tuning check) must be run prior to the initial calibration and each continuing calibration and must meet all method-specified criteria before analysis may continue. Initial calibration is required before any samples are analyzed and must include a blank and a minimum of five different concentrations as specified in the method. A DFTPP tuning check and a continuing calibration check, including the mid-range standard and a blank, must be performed at the beginning of each 12-hour period during which analyses are performed.

7.2.3 HRGC/HRMS Dioxin/Furan Analyses

For Dioxin/Furan compounds, the high resolution gas chromatograph/high resolution mass spectrometer (HRGC/HRMS) system will be tuned and calibrated in accordance with the appropriate analytical method. A Perfluorokerosene (PFK) instrument performance check (tuning check) must be run prior to the initial calibration and each continuing calibration and must meet all method-specified criteria before analysis may continue. Initial calibration is required before any samples are analyzed and must include a blank and a minimum of five different concentrations as specified in the method. A PFK tuning check and a continuing calibration check, including the mid-range standard and a blank, must be performed at the beginning of each 12-hour period during which analyses are performed.

7.2.4 GC Pesticide/PCB/Herbicide Analyses

For Pesticide/PCB/Herbicide, the gas chromatograph (GC) system will be calibrated in accordance with the appropriate analytical method. Initial calibration is required before any samples are analyzed and must include a blank and a minimum of five different concentrations as specified in the method. A continuing calibration check, including the mid-range standard and a blank, must be performed at the beginning of each 10-sample period during which analyses are performed.

7.2.5 ICP Inorganic Analyte Analyses

For metals, the inductively coupled plasma (ICP)-atomic emission spectrometry system will be calibrated in accordance with the appropriate analytical method. Initial calibration is required before any samples are analyzed and must include a preparation blank. A continuing calibration check and a blank must be performed at the beginning of each 10-sample period during which analyses are performed.

7.2.6 Atomic-Absorption Mercury Analysis

For mercury, the atomic absorption spectrophotometer (AA) will be calibrated in accordance with the appropriate analytical method. Initial calibration is required before any samples are analyzed and must include a preparation blank. A continuing calibration check and a blank must be performed at the beginning of each 10-sample period during which analyses are performed.

7.2.7 Miscellaneous Parameters

Calibration and standardization requirements for the analysis of the remaining parameters will be performed as specified in the applicable analytical methods and manufacturer's recommendation.

8.0 ANALYTICAL AND MEASUREMENT PROCEDURES

Samples will be subjected to field and laboratory parameter measurement as necessary based on the sample matrix and location under investigation. The analytical program for environmental samples collected at each anticipated location is provided in Section 5.4, 5.5, and 5.6 of the WP.

Groundwater chemical/physical parameters to be measured using field instrumentation include:

- temperature,
- specific conductance,
- pH,
- turbidity, and
- ORP.

Soil chemical/physical parameters to be measured using field instrumentation include:

- Soil headspace organic vapor

Measurement of field parameters and calibration of field instruments are discussed in Section 16 of the USEPA EISOPQAM.

The analytical laboratory responsible for the chemical analyses will be NFESC-approved, certified by the National Environmental Laboratory Accreditation Conference (NELAC) for all analyses that are requested by TtNUS. Documentation of the certifications will be provided to TtNUS as described in the TtNUS analytical Statement of Work for the contracted laboratory.

Environmental samples submitted for VOC, SVOC, Pesticide/PCB, Herbicide, Dioxin/Furan, or inorganic analysis will be analyzed in accordance with current SW-846 methods. Groundwater samples for miscellaneous parameter analyses will be analyzed in accordance with current EPA approved methods. Table 8-1 provides a summary of the laboratory analytical methods for the NCBC Gulfport Site 4 sampling program.

A complete list of the target compounds/analytes RQLs is provided in Section 1.4.2.2 of this QAPP. Data generated through use of the SW-846 method protocols will be reported to the RQL for nondetected compounds from organics analysis. Compounds which are positively identified and which can be quantitated at concentrations less than the RQL, but above the calculated method detection limit (MDL) will be reported as specified in the appropriate analytical method. Inorganic analytes which are positively identified will be reported to the Instrument Detection Limit (IDL). Environmental data generated through use of non-SW-846 methods will be reported to the laboratory's Reporting Limit (RL). An analyte's RL is an expression of the method detection limit with adjustments made to ensure that the precision and accuracy requirements of the method are attainable at the RL. The RLs are not provided in the tables in Section 1.4.2.2 since these values vary based on the laboratory.

Quantitation and detection limits will also be adjusted, as necessary, based on dilutions and sample volume.

TABLE 8-1

SUMMARY OF ORGANIC, INORGANIC, and MISCELLANEOUS ANALYTICAL PROCEDURES
NCBC GULFPORT SITE 4, GULFPORT, MISSISSIPPI

Analytical Parameter	Analytical Method
TCL Volatile Organics	SW-846 8260B (25mL purge)
TCL Semi-Volatile Organics	SW-846 8270D
TCL Pesticides	SW-846 8081B
TCL PCBs	SW-846 8082A
Herbicides	SW-846 8151A
Dioxins/Furans	SW-846 8290A
Cyanide	SW-846 9012
TAL Metals	SW-846 6010B
Organophosphorous Pesticides	SW-846 8141A
Anions	EPA 300.0
Dissolved Gasses	RSK SOP147 and 175
Dissolved Hydrogen	Bubblestrip method
TOC	SW-846 9060

TCL – Target Compound List
TAL – Target Analyte List

9.0 PREVENTIVE MAINTENANCE PROCEDURES

Measuring equipment used in environmental monitoring or analysis for the NCBC Gulfport Site 4 sampling program shall be maintained in accordance with the manufacturer's operation and maintenance manuals. Equipment and instruments shall be calibrated in accordance with the procedures, and at the frequency, discussed in Section 7.0 (Calibration Procedures and Frequency). Preventive maintenance for field and laboratory equipment is discussed in the remainder of this section.

9.1 FIELD EQUIPMENT PREVENTIVE MAINTENANCE

TtNUS has established a program for the maintenance of field equipment to ensure the availability of equipment in good working order when and where it is needed. This program consists of the following elements:

- The TtNUS equipment manager keeps an inventory of the equipment in terms of items (model and serial number), quantity, and condition. Each item of equipment is signed out when in use, and its operating condition and cleanliness checked upon return.

- The equipment manager conducts routine checks on the status of equipment and is responsible for the stocking of spare parts and equipment readiness. The equipment manager also maintains the equipment manual library.

- The FOL is responsible for working with the equipment manager to make sure that the equipment is tested, cleaned, charged, and calibrated in accordance with the manufacturer's instructions and Section 16 of the USEPA EISOPQAM before being taken to the job site and during field activities.

- During calibration, an appropriate maintenance check is performed on each piece of equipment. Any problems encountered while operating the instrument will be recorded in the field log book including a description of the symptoms and corrective actions taken.

- If a problem with the equipment is detected or should require service, the equipment should be logged, tagged, and segregated from equipment in proper working order. Use of the instrument will not be resumed until the problem is resolved.

9.2 LABORATORY INSTURMENT PREVENTIVE MAINTENANCE

Proper maintenance of laboratory instruments and equipment is essential to ensuring their readiness when needed. Based on the instrument manufacturer's recommendations, maintenance intervals are established for each instrument. All major instruments must be labeled with a model number and serial number, and a maintenance logbook must be maintained for each major instrument. Personnel must be alert to the maintenance status of the equipment they are using at all times.

9.2.1 Major Instruments

Table 9-1 provides a summary of preventive maintenance procedures typically performed for key analytical instruments. Maintenance of key instruments is sometimes covered under service contracts with external firms. These contracts provide for periodic routine maintenance to help guard against unexpected instrument downtime. The contracts also provide for quick response for unscheduled service calls when malfunctions are observed by the operator.

The use of manufacturer recommended grades or better of supporting supplies and reagents is also a form of preventive maintenance. For example, gases used in the various gas chromatographs and metals instruments should be of sufficient grade to minimize fouling of the instrument. The routine use of septa, chromatographic columns, ferrules, AA furnace tubes, and other supporting supplies from reputable manufacturers will assist in averting unnecessary periods of instrument downtime.

9.2.2 Refrigerators/Ovens

The temperatures of refrigerators used for sample storage and drying ovens will be monitored a minimum of once daily. The acceptable range for refrigerator temperatures is 4°C ±2°C. Required temperatures of ovens will vary based on the analytical methods for which the ovens are used. The temperatures will be recorded on temperature logs. The logs will contain the following information at a minimum:

- Date
- Temperature
- Initials of person performing the check

Maintenance of the logs is typically the responsibility of the sample custodian. However, assignment of responsibilities for temperature monitoring to specific personnel does not preclude the participation of other laboratory personnel. If unusual temperature fluctuations are noted, it is the responsibility of the observer to immediately notify the person in charge of the equipment item that the discrepancy has occurred before the condition of the samples is compromised.

Unstable or fluctuating temperatures may be indicative of malfunctions in the cooling or heating system. On the other hand, the instability may be due to frequent opening of the door. Regardless of the cause, such an observation must be investigated, and modifications must be made to access procedures or repairs to equipment must be made to prevent jeopardizing the integrity of the samples.

TABLE 9-1

TYPICAL PREVENTIVE MAINTENANCE FOR KEY ANALYTICAL INSTRUMENTS
NCBC GULFPORT SITE 4, GULFPORT, MISSISSIPPI

Instrument	Preventive Maintenance	Maintenance Frequency
GC/MS	Bake oven, replace septum, check carrier gas, clip column, clean injection port. Replace solvent washes and clean syringe.	As required. Daily.
GC	Bake oven, replace septum, check carrier gas, clip column, clean injection port. Replace solvent washes and clean syringe.	As required. Daily.
HRGC/HRMS	Bake oven, replace septum, check carrier gas, clip column, clean injection port. Replace solvent washes and clean syringe.	As required. Daily.
ICP	Change sample introduction tubing, clean nebulizer, clean spray chamber, clean torch, manual profile, and automatic profile optics.	As required.
CVAA	Change sample introduction tubing, change drying cell, re-zero detector	As required

10.0 INTERNAL QUALITY CONTROL CHECKS

Field-related QC checks were discussed in Section 3.0 of this QAPP. This section provides additional information regarding internal quality control checks for the field and the laboratory.

10.1 FIELD QUALITY CONTROL CHECKS

QC procedures for field measurements will include calibrating the instruments as discussed in Section 16 of the USEPA EISOPQAM. Assessment of field sampling precision and bias will be made by collection of field duplicates and rinsate blanks for laboratory analysis as discussed in Section 3.6 of this QAPP.

10.2 LABORATORY QUALITY CONTROL CHECKS

The subcontract laboratory will have a QC program that ensures the reliability and validity of the analyses performed at the laboratory. Internal quality control procedures for analyses will comply with the applicable analytical method requirements.

Several internal laboratory QC checks are briefly discussed in the remainder of this section.

Laboratory method blanks are prepared and analyzed in accordance with the analytical method employed to indicate whether contaminants originating from laboratory sources have been introduced and may have affected environmental sample analyses. A method blank generally consists of an aliquot of analyte-free water that is subjected to the same preparation and analysis procedures as the environmental samples undergoing analysis. With the exception of recognized volatile and semivolatile common laboratory contaminants (e.g., methylene chloride, acetone, 2-butanone, and phthalates), method blanks must not contain detected levels of target analytes greater than the reported quantitation limits (above 2.5X the RQL for methylene chloride and above 5X the RQL for acetone and 2-butanone). Under no circumstances are laboratory method blank contaminant values subtracted from environmental sample analysis results.

Matrix spike analysis for organic fraction analyses is performed in duplicate as a measure of laboratory precision. For inorganic (metals) analyses, one matrix spike analysis and one **laboratory duplicate** analysis are performed for every 20 environmental sample analyses of like matrix. With the exception of VOC MSD analyses, laboratory duplicates are prepared by thoroughly mixing and splitting a sample aliquot into two portions and analyzing each portion following the same analytical procedures that are used for the environmental sample analyses. For VOC MSD analyses, a second sample aliquot is used for analysis in order to avoid VOC constituent loss. The field crew provides extra volumes of sample matrices designated for laboratory quality control analyses, as required.

Surrogates are organic compounds (typically brominated, fluorinated, or isotopically labeled) which are similar in nature to the compounds of concern, and which are not likely to be present in environmental media. Surrogates are spiked into each sample, standard, and method blank prior to analysis, and are used only in organic chromatographic analysis procedures as a check of method effectiveness and extraction efficiency. As discussed in Section 3.0 of this QAPP, surrogate recoveries are evaluated against control limits specified in the associated method, where applicable, or laboratory-derived control limits.

Laboratory control samples serve to monitor the overall performance of each step during the analysis, including the sample preparation. Laboratory control sample analysis will be performed for volatiles and as required by the applicable analytical method. Aqueous LCS results must fall within the control limits specified in the analytical method, where applicable, or established by the laboratory. Aqueous LCSs shall be analyzed utilizing the same sample preparations, analytical methods, and QA/QC procedures as employed for the samples.

Internal standard performance criteria ensure that organic GC/MS analysis sensitivity and response are stable during every analytical run. Internal standard area counts for samples and blanks must not vary by more than a factor of two (- 50% to + 100%) from the associated calibration standard. The retention time of the internal standards in samples and blanks must not vary by more than ±30 seconds from the retention time of the associated calibration standard.

11.0 DATA REDUCTION, VALIDATION, AND REPORTING

This section describes the procedures to be used for data reduction, review, and reporting for the NCBC Gulfport Site 4 sampling program. Data generated during the course of the investigation will be maintained in hardcopy format by TtNUS in the Naval Facilities Engineering Command Southern Division designated central files located in TtNUS' Pittsburgh, Pennsylvania office. In addition to the central files, photocopies of hardcopy data (as well as electronic data) will be maintained in the Chemistry/Toxicology/Risk Assessment Department database records files located in TtNUS' Pittsburgh, Pennsylvania office. Upon completion of the contract, the data files will be relinquished to the Navy.

11.1 DATA REDUCTION

Data reduction will be completed for both field measurements and laboratory-generated analytical data. Field data reduction will be relatively limited versus the degree of laboratory data reduction required for the project. Reduction of both field data and laboratory data are discussed in the remainder of this section.

11.1.1 <u>Field Data Reduction</u>

Field groundwater data will be recorded from on-site water quality testing for general indicator parameters including pH, specific conductance, turbidity, temperature, and ORP. Field soil data will be recorded from on-site soil headspace organic vapor testing.

The field parameters will be recorded in the site logbook or on sample log sheets immediately after the measurements are taken and later encoded in the NCBC Gulfport database for presentation in the Report. If an error is made in the logbook, the error will be legibly crossed out (single-line strikeout), initialed and dated by the field member, and corrected in a space adjacent to the original (erroneous) entry. No calculations will be necessary to reduce these data for inclusion in the Report. Field data will be entered in the electronic database manually, and the entries will be verified by an independent reviewer to make sure that no "transcription" errors occurred.

Field groundwater parameter measurements will be recorded and reported in the following units:

- Hydronium ion concentration (standard pH units)
- Temperature (degrees Celsius)
- Specific Conductance (uMhos/cm)
- Turbidity (Nephelometric turbidity units, NTUs)

Standard pH units as specified above are the negative logarithm (base 10) of the hydronium ion concentration in moles/liter.

Field soil parameter measurements will be recorded and reported in the following units:

- Organic vapor concentration in parts per million (ppm)

11.1.2 Laboratory Data Reduction

Laboratory data reduction of analytical results generated via non-SW-846 methods will be completed in accordance with the applicable analytical methods.

Laboratory analytical data will be reported using standard concentration units to ensure comparability with regulatory standards/guidelines and previous analytical results. Reporting units for aqueous matrices (groundwater, surface water, aqueous QA/QC) for the classes of chemicals under consideration are as follows:

- Volatile organics - µg/L
- Semi-Volatile organics - µg/L
- Pesticides - µg/L
- PCBs – ug/L
- Herbicides – ug/L
- Inorganics (metals) – mg/L
- Dioxins/Furans – pg/L
- Dissolved Gases – mg/L

Reporting units for solid matrices (soil and/or sediment) for the classes of chemicals under consideration are as follows:

- Volatile organics - µg/kg
- Semi-Volatile organics - µg/kg
- Pesticides – µg/kg
- PCBs - µg/kg
- Dioxins/Furans – ng/kg
- Inorganics (metals) – mg/kg

Field Quality Control sample results will be included in the database for the NCBC Gulfport Site 4 sampling program. Specifically, the analytical results for field duplicates, trip blanks, and rinsate blanks will be provided. The results for field QC samples will be considered during the course of data review (in concert with laboratory method blanks) to eliminate false positive results according to the 5- and 10-times rules specified in the National Functional Guidelines for Organic Review. The results for laboratory QC samples such as method blanks will not be presented in the Report database. In addition, only the original (unspiked) sample results for MS/MSD samples will be provided in the database.

11.2 DATA VALIDATION

Validation of field measurements and laboratory analytical data are discussed in this section. Validation of field data will be limited to real time checks. Laboratory analytical data will be reviewed against data validation rules described below. Review of field measurement data is discussed in Section 11.2.1. Review of laboratory analytical data is discussed in Section 11.2.2.

11.2.1 Field Measurement Data Validation

Field measurements will not be subjected to a formal data validation process. However, field technicians will ensure that the equipment used for field measurement is performing accurately via calibration as discussed in Section 16 of the USEPA EISOPQAM. The FOL will ensure that the field tests are performed in accordance with the test manufacturer's instruction and that the field meters are used in accordance with the instrument's manufacturer's instruction. The results of field tests and measurements will be recorded in field logbooks or sample log sheets. This information will be reviewed by the FOL to verify the information was recorded properly (i.e. for transcription errors) and the proper field analyses were performed. The field data entered into the electronic database will be independently reviewed for transcription errors. A comparison will be made of the number of samples actually collected relative to number of samples planned for collection to ensure that the intended samples have been collected.

11.2.2 Laboratory Data Review

One hundred percent of the laboratory data will undergo a full data validation. A full data validation includes, but is not limited to:

- sample holding times,
- method blank analyses,
- initial and continuing calibration standards,
- data completeness,

- reported detection limits,
- lab control sample analysis,
- matrix spike/ matrix spike duplicate analysis, and
- duplicate sample analyses.

Review of analytical data will be completed by the TtNUS Chemistry Department located in TtNUS' Pittsburgh, Pennsylvania office. Final review and approval of reviewed deliverables will be completed by the Department's Data Validation Manager. The TOM will maintain contact with the Data Validation Manager to ensure that management of the acquired data proceeds in an organized and expeditious manner.

Organic data analytical results will be reviewed versus the applicable analytical method. Data will be accepted, rejected, or qualified based on the results of the limited review items. Guidelines established in the USEPA National Functional Guidelines for Organic Data Review (October 1999), the USEPA National Functional Guidelines for Inorganic Data Review (February 1994), and the NFESC guidelines "Navy Installation Restoration Chemical Data Quality Manual" (September 1999) will be used as guidance to define the criteria for the full data validation items.

11.3 DATA REPORTING

11.3.1 Field Measurement Data Reporting

Field data will be reported in the units discussed in Section 10.1.1. The Report will include a comprehensive database including all field measurements. Field measurements will be transferred from the site logbook or sample log sheets to the electronic database manually and will be reviewed for accuracy by an independent reviewer. Transcription of field measurements to the electronic database will be completed shortly after completion of the field investigation and prior to receipt of laboratory analytical data.

Hard copy records regarding field measurements (i.e., field logbooks, sampling logbooks, and sample log sheets) will be placed in TtNUS' Southern Division central files upon completion of the field effort. Entry of these results in the database will require removal of these results from the files. Outcards will be used to document the removal of any such documentation from the files (date, person, subject matter). Field measurement data will be reported in an appendix to the Report at a minimum and may also be reported in summary fashion if they are indicative of the presence of contamination (e.g., high specific conductance readings).

11.3.2 Laboratory Data Reporting

Data reported by the laboratory will be in accordance with the reporting format described in TtNUS' analytical Statement of Work for the contracted laboratory. All pertinent quality control data including method blanks, standards analysis, calibration information, etc. will be provided for the non-SW-846 method analyses. Case narratives and a certificate of analysis will be provided for each Sample Delivery Group (SDG).

Environmental and field QC sample results (trip blanks, field duplicates, rinsate blanks) will be included in the Report as an appendix. The database will include pertinent sampling information such as sample number, sampling date, general location, depth, and survey coordinates (if applicable). Sample-specific detection limits will be reported for nondetected analytes. Units will be clearly summarized in the database and will conform to those identified in Section 11.1.2. The analytical data may also be reported in summary fashion within the body of the Report text in tabular and graphic fashion.

Data will be handled electronically pursuant to the electronic deliverable requirements specified in TtNUS' purchase order with analytical laboratories. This agreement requires the analytical laboratories to provide data in both hardcopy and electronic form. The laboratory will provide a 28 calendar-day turnaround time for the delivery of the SDG in both hardcopy and electronic format. The original electronic diskettes and the original hardcopy analytical data are maintained in TtNUS' Southern Division central files as received.

Data review will be completed using the hard copy data. Upon completion of the review of a SDG and review by the Data Validation Manager, review qualifiers will be entered in the electronic database and will be subjected to independent review for accuracy. During this review process, the electronic data base printout will also be contrasted with the hard copy data to ensure that the hard copy data and electronic data are consistent.

In addition, a summary of the data qualifiers for all project samples will be prepared. This summary will include a list of chemicals identified as laboratory and/or field QC blank contaminants, holding time exceedances, samples exhibiting field duplicate/replicate imprecision as well as affected chemicals, rejected results and associated specific causes, and general causes of estimated results. This summary will facilitate the preparation of a summary of the data review results and completeness assessment for inclusion in the Report.

12.0 SPECIFIC ROUTINE PROCEDURES USED TO ASSESS DATA PRECISION, ACCURACY, COMPLETENESS, FIELD DUPLICATES, AND DATA USABILITY

Compliance with the QC objectives outlined in Section 3.0 will be monitored via two separate mechanisms. Precision and accuracy will be assessed through data, while compliance with the completeness objectives for field and laboratory data/measurement will be calculated by hand (field measurements) and electronically via a database subroutine (laboratory data). Information necessary to complete the precision and accuracy calculations will be provided in electronic and hardcopy form by the subcontract laboratory. Equations to be used for the precision, accuracy, and completeness assessment are outlined in the remainder of this section.

12.1 ACCURACY ASSESSMENT

To assure the accuracy of the analytical procedures, a minimum of 1 of every 20 samples is spiked with a known amount of the analyte or analytes to be evaluated. The spiked sample is then analyzed. The increase in concentration of the analyte observed in the spiked sample, because of the addition of a known quantity of the analyte, compared to the reported value of the same analyte in the unspiked sample determines the percent recovery. Control charts are plotted for each commonly analyzed compound and kept on matrix-specific and analyte-specific bases. The %R for a spiked sample is calculated according to the following formula:

$$\%R = \frac{\text{Amount in Spiked Sample} - \text{Amount in Sample}}{\text{Known Amount Added}} \text{ X } 100\,\%$$

12.2 PRECISION ASSESSMENT

Duplicate samples and MS/MSD samples are prepared and analyzed at a minimum frequency of 1 per every 20 environmental samples. Duplicate samples are provided by the field crew.

MS/MSD samples are prepared by spiking each of the aliquots with a known amount of analyte. The duplicate samples are handled just like the other environmental samples included in the analytical sample set. The RPD between the sample (or MS) and duplicate sample (or MSD) is calculated and plotted. The RPD is calculated according to the following formula:

$$RPD = \frac{\text{Amount in Sample} - \text{Amount in Duplicate}}{0.5\ (\text{Amount in Sample} + \text{Amount in Duplicate})} \text{ X } 100\,\%$$

12.3 COMPLETENESS ASSESSMENT

Completeness is the ratio of the number of valid sample results to the total number of sample results expected to be obtained for the project as a whole. Following the completion of the analytical testing and data validation, the percent completeness will be calculated by the following equation:

$$\text{Completeness} = \frac{\text{(number of valid measurements)}}{\text{(number of measurements planned)}} \text{ X } 100\ \%$$

The results of the data validation process and the completeness assessment will be summarized in the Report using the summary format discussed in Section 11.3.2 and an electronic database subroutine.

12.4 FIELD DUPLICATE ASSESSMENT

Field duplicate sample results and their associated sample results will be assessed using the calculated average of the two results, when performing risk and ecological assessments.

$$= \text{(sample result + duplicate result) X } 0.5$$

12.5 DATA USABILITY ASSESSMENT

Data validation, accuracy, precision, completeness, and duplicate assessments are completed with regards to specific criteria. The results of the validation and assessments are applied to project specific standards, which determine the usability of the data. The impact of any rejected data must be addressed to determine if the overall project objective has been compromised. This section details the technical criteria on which the validation and assessments are based, the project-specific standards applied to the "qualified data", and the impact of rejected data on the overall project objective.

Technical Criteria

Accuracy, precision, and duplicate assessments (the calculations are detailed in Sections 12.1, 12.2, and 12.4, respectively) are based on the technical criteria listed in Section 3 of this QAPP. A completeness assessment is also performed. The data must meet 95% completeness (the calculation is detailed in Section 12.3) to fulfill the completeness standard as stated in Section 3.3 of this QAPP. Guidelines established in the USEPA National Functional Guidelines for Organic Data Review (October 1999), the USEPA National Functional Guidelines for Inorganic Data Review (February 1994), and the NFESC guidelines "Navy Installation Restoration Chemical Data Quality Manual" (September 1999) will be used as guidance to define the criteria for the limited data validation. The results of the assessments and the validation provide the data user with "qualified data".

Standards

Project-specific standards addressed in this section are used to determine the usability of the qualified data. The following list details the standards to be used when determining the usability of the data:

- Any data collected using procedures not specified in the Work Plan and without prior approval from the TOM will be rejected.
- If the completeness assessment returns a less than 95% complete, all data will be rejected.
- Any data point rejected during the data validation or assessments will be rejected.
- If a data point is qualified as estimated during the validation or assessments the following tests will be implemented:

1. Will the qualified result affect any decisions for the project or site?
   - No – then the result is rejected and not included.
   - Yes – continue to Test #2.
2. Could the result be biased high?
   - No – continue to Test #3.
   - Yes – continue to Test #4.
3. Could the result be biased low?
   - No – then the result is accepted and included.
   - Yes – continue to Test #4.
4. If the result is biased high or low, how will the result affect the decisions for the project or site?
   - If a biased high contamination result will result in the exceedance of MCLs, the result will be accepted and included.
   - If a biased high contamination result will result in no exceedance of MCLs, the result will be accepted and included.
   - If a biased low contamination result will result in no exceedance of MCLs, the result will be accepted and included.
   - If a biased low contamination result will result in the exceedance of MCLs, the result will be accepted and included.

Using these standards to determine the usability of the data will ensure that the integrity of the project objective is maintained. Maintaining the project objective will ensure that accurate decisions are made when determining the most appropriate action for the project or site. Rejected data must be considered to determine the impact on the decisions.

Rejected Data

Rejected data can have significant impact on the decisions that will determine the status of the project or site. Specific questions about the rejected data must be addressed and answered before making any final decisions. Question to be addressed about rejected data are:

Is it possible that MCLs will not be exceeded when the rejected data is not included?

- Yes – Additional data will be collected to determine if non-rejected data will or will not exceed MCLs.
- No – Additional data will not be collected. Final decisions will be made without the rejected data.

Answers to this question will determine if and how the project objective will be met.

Using technical criteria to determined the validity of the collected data, project-specific standards to determine the usability of the qualified data, and determining the impact of rejected data on project objectives will ensure that quality data and informed decisions are made with respect to the project objective and future studies at the site.

13.0 PERFORMANCE AND SYSTEM AUDITS

Performance and system audits will be performed periodically to ensure that work is being implemented in accordance with the approved Project Plans and in an overall satisfactory manner. Such audits will be performed by various personnel and will include evaluation of field, laboratory, data review, and data reporting processes. Examples of pertinent audits are as follows:

- The FOL will supervise and check daily that the field measurements are made accurately, equipment is thoroughly decontaminated, samples are collected and handled properly, and fieldwork is documented accurately and neatly.

- Performance and system audits of the laboratory will be performed regularly (every 18 months) by a Navy Contractor (internal), and in accordance with the Laboratory Quality Assurance Plan (internal).

- Data reviewers will evaluate (on a timely basis) the chemical analytical data packages submitted by the laboratory. The data reviewers will check that the data were obtained through use of an approved methodology, that the appropriate level of QC effort and reporting was conducted, and whether or not the results are in conformance with QC criteria. Based on these factors, the data reviewer will generate a report describing data limitations, which will be reviewed internally by the Data Validation Manager prior to submittal to the TOM.

- A formal audit of the field sampling procedures may be conducted by the TtNUS Quality Assurance Manager (QAM) or designee in addition to the auditing that is an inherent part of the daily project activities. The purpose of this audit is to ensure that sample collection, handling, and shipping protocols, as well as equipment decontamination and field documentation procedures, are being performed in accordance with the approved Project Plans and SOPs. An audit will be performed if the TtNUS TOM, TtNUS QAM, Navy Remedial Project Manager, USEPA Regulator, or FDEP Project Manager develops concerns with regards to the field sampling effort.

14.0 CORRECTIVE ACTION

Under TtNUS' QA/QC program, it is required that any and all personnel noting conditions adverse to quality report these conditions immediately to the TOM and the QAO. These parties, in turn, are charged with performing root-cause analyses and implementing appropriate corrective action in a timely manner. It is ultimately the responsibility of the QAO to document all findings and corrective actions taken and to monitor the effectiveness of the corrective measures performed.

14.1 FIELD CORRECTIVE ACTION

Field nonconformances or conditions adverse to quality must be identified and corrected as quickly as possible so that work integrity or quality of product is not compromised. The need for corrective action may arise based on deviations from Project Plans and procedures, adverse field conditions, or other unforeseen circumstances. Corrective action needs may become apparent during the performance of daily work tasks or as a consequence of internal or external field audits.

Corrective action may include resampling and may involve amending previously approved field procedures. If warranted by the severity of the problem (e.g., if a change in the approved Project Plan documents or SOPs is required), the Navy will be notified in writing via a Field Task Modification Request (FTMR), and Navy approval (in conjunction with USEPA Region IV and MDEQ) will be obtained. The FOL is responsible for initiating FTMRs; an FTMR will be initiated for all deviations from the Project Plan documents, as applicable. An example of an FTMR is provided as Figure 14-1. Copies of all FTMRs will be maintained with the onsite project planning documents and will be placed in the final evidence file.

Minor modifications to field activities such as a slight offset of a boring location will be initiated at the discretion of the FOL, subject to onsite approval by NCBC Gulfport personnel. Approval for major modifications (e.g., elimination of a sampling point) must be obtained via an FTMR.

FIGURE 14-1

TETRA TECH NUS, INC.
FIELD TASK MODIFICATION REQUEST FORM

Client Identification	Project Number	FTMR Number

To______________________ Location______________ Date______________

Description:

____
____
____
____

Reason for Change:

____
____
____
____

Recommended Disposition:

____
____
____
____

____
Field Operations Leader (Signature, if applicable) Date

Disposition:

____
____
____
____

____
Task Order Manager (Signature, if required) Date

____
Distribution:
Program Manager — Others as required______________
Quality Assurance Officer ______________
Task Order Manager ______________
Field Operations Leader ______________

14.2 LABORATORY CORRECTIVE ACTION

In general, laboratory corrective actions are warranted whenever an out-of-control event or potential out-of-control event is noted. The specific corrective action taken depends on the specific analysis and the nature of the event. Generally, the following occurrences alert laboratory personnel that corrective action may be necessary:

- QC data are outside established warning or control limits;
- Method blank analyses yield concentrations of target analytes above acceptable levels;
- Undesirable trends are detected in spike recoveries or in duplicate RPDs;
- There is an unexplained change in compound detection capability;
- Inquiries concerning data quality are received; and
- Deficiencies are detected by laboratory QA staff audits or from performance evaluation sample test results.

Corrective actions are typically documented for out-of-control situations on a corrective action form. Using a corrective action form, any employee may notify the QAO of a problem. The QAO generally initiates the corrective action by relating the problem to the appropriate Laboratory Manager and/or Internal Coordinator, who then investigates or assigns responsibility for investigating the problem and its cause. Once determined, an appropriate corrective action is approved by the QAO. Its implementation is verified and documented on the corrective action form and is further documented through audits.

14.3 CORRECTIVE ACTION DURING DATA REVIEW AND DATA ASSESSMENT

The need for corrective action may become apparent during data review and assessment. Data is sometimes qualified or rejected due to deviances from project-SOPs or project-specific control limits. Section 13.4 details the technical criteria and project-specific standards used when determining the usability of the data. The impact of rejected data and corrective actions to be used when data is rejected is also discussed in Section 13.4. The performance of rework or instituting a change in work procedures, are possible corrective actions relevant to data evaluation activities. The TOM will be responsible for approving the implementation of corrective action.

15.0 QUALITY ASSURANCE REPORTS TO MANAGEMENT

QA reports to management will be provided in three primary formats during the course of the NCBC Gulfport Site 4 sampling program. Data review letter reports will be prepared on a SDG-specific basis and will summarize QA issues for the subcontract laboratory data. In addition, written weekly reports summarizing accomplishments and QA/QC issues during the field investigation will be provided by the FOL. Finally, monthly progress reports are provided by the TOM. In addition, a summary of data review qualifiers and a completeness assessment for all project samples will be included in the Report.

15.1 CONTENTS OF PROJECT QUALITY ASSURANCE REPORTS

The data review letter reports address major and minor laboratory noncompliances as well as noted sample matrix effects. In the event that major problems occur with the analytical laboratory (e.g., holding time exceedances or calibration noncompliances, etc.) the Data Validation Manager will notify the TOM, the Technical Program Manager, and the Laboratory Services Coordinator. Such notifications (if necessary) are typically provided via internal memoranda and are placed in the project file. Such reports contain a summary of the noncompliance, a synopsis of the impact on individual projects, and recommendations regarding corrective action and compensational adjustments. Corrective actions are initiated at the program level.

The FOL will provide the TOM with weekly reports regarding accomplishments, deviations from the WP, upcoming activities, and a QA summary during the course of the field investigation. In addition, monthly project review meetings are held for all active Navy CLEAN III projects. Issues discussed at the project review meeting include all aspects of budget and schedule compliance, and QA/QC problems. The TOM provides a monthly progress report to the Navy, which addresses the project budget, schedule, accomplishments, planned activities, required revisions of the QAPP, and QA/QC issues and intended corrective actions.

15.2 INDIVIDUALS RECEIVING/REVIEWING QUALITY ASSURANCE REPORTS

Data review QA Reports are provided to the TOM for inclusion in the project files. In the event that major problems are observed for a given laboratory, the Program Manager, Deputy Program Manager, QAM, TOM, QAO, and Laboratory Services Coordinator are provided with copies of the QA report. Weekly field progress reports are provided to the TOM. Monthly progress reports are provided to the Navy CLEAN III Program Manager and the Navy CLEAN III Contracting Officers Technical Representative.

APPENDIX C

HEALTH AND SAFETY PLAN (HASP)

HEALTH AND SAFETY PLAN
For
SITE 4 GOLF COURSE LANDFILL
FIELD INVESTIGATION
At the
NAVAL CONSTRUCTION BATTALION CENTER
GULFPORT
GULFPORT, MISSISSIPPI

Naval Facilities Engineering Command

Southern Division
Naval Facilities Engineering Command
Contract Number N62467-94-D-0888
Contract Task Order 0283

June 2004

HEALTH AND SAFETY PLAN
FOR
SITE 4 – GOLF COURSE LANDFILL
FIELD INVESTIGATION
AT THE
NAVAL CONSTRUCTION BATTALION CENTER GULFPORT
GULFPORT, MISSISSIPPI

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION-NAVY (CLEAN) CONTRACT

Submitted to:
Southern Division
Naval Facilities Engineering Command
2155 Eagle Drive
North Charleston, South Carolina 29406

Submitted by:
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CONTRACT NUMBER N62467-94-D-0888
CONTRACT TASK ORDER 0283

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1.0 INTRODUCTION

The objective of this Health and Safety Plan (HASP) is to provide the minimum safety practices and procedures to Tech NUS (TtNUS) personnel conducting monitoring well installation and media sampling activities in support of these Site Evaluation activities at the Naval Construction Battalion Center, located in Gulfport Mississippi.

Authorization: This Health and Safety Plan (HASP) and the work described herein have been completed under the authorization of:

Contract: Comprehensive Long Term Environmental Action – Navy (CLEAN) – Southern Division Naval Facilities Engineering Command

Contract Number: N62467-94-D-0888

Contract Task Order Number (CTO): 0283

Statement of Work/Application: This HASP will support the following activities

- DPT - Surface and subsurface soils and groundwater sampling
- Hollow Stem Auger (HSA) Drilling and Monitoring Well Installation
- Multi-media Sampling including
- Sediment/surface water
- Monitoring Well Dvelopment
- Aquifer Testing – Slug Testing
- Geophysical/Geographical Land Surveying
- IDW Management

Proposed Dates of Work: June 2004

Compliance: The elements of this HASP are intended to be in compliance with the requirements established by:

- OSHA 29 CFR 1910.120, "Hazardous Waste Operations and Emergency Response" (HAZWOPER)
- Applicable sections of 29 CFR 1926 "Safety and Health Regulations for Construction."
- Tetra Tech NUS Health and Safety Program
- NCBC Gulfport Policies and Procedures, where and as applicable.

This HASP must be accompanied by the Tetra Tech NUS, Inc. Health and Safety Guidance Manual (TtNUS HSGM). The Guidance Manual provides additional information in the areas of program support, standard operating procedures, and safe work practices.

Modifications/Changes: This HASP has been prepared using the latest available information regarding known or suspected chemical contaminants and potential and foreseeable physical hazards associated with the planned work at Naval Construction Battalion Center (NCBC) Gulfport. The following conditions are considered sufficient basis review and possible changes to this document

- The addition or modification of activities/tasks outside of those specified in Section 4.0, Scope of Work.
- New information becomes available through the course of the investigation or from outside sources.

All changes to this HASP will be requested through the Project Manager (PM) to the Tetra Tech NUS Health and Safety Manager (HSM). It is the responsibility of the PM to notify all affected personnel of all changes to this HASP.

1.1 KEY PROJECT PERSONNEL AND ORGANIZATION

This section defines responsibilities for site safety and health for TtNUS and subcontractor employees conducting environmental sampling and other field activities. Personnel assigned to these positions shall exercise the primary responsibility for on site health and safety. These persons will be the primary point of contact for any questions regarding the safety and health procedures and the selected control measures.

- The TtNUS TOM is responsible for the overall direction of health and safety for this project.

- The PHSO is responsible for the development of this HASP in accordance with applicable OSHA regulations as specified in Section 1.0 and to serve as technical support.

- The TtNUS Field Operations Leader (FOL) is responsible for implementation of the HASP with the assistance of an appointed SHSO. The FOL manages field activities, executes the work plan, and enforces safety procedures as applicable to the work plan.

- The SHSO supports site activities by advising the FOL on all aspects of health and safety on site as they may pertain to regulatory requirements or task related hazards. These duties may include:

  - Verify training and medical status of on-site personnel in relation to site activities.

- Assist and represent TtNUS coordinating emergency services (if needed)
- Provide elements site-specific training for on site personnel.
- Coordinating health and safety activities
- Selecting, applying, inspecting, and maintaining personal protective equipment
- Establishing work zones and control points
- Implementing air monitoring procedures
- Implementing hazard communication, respiratory protection, and other associated safety and health programs

- Compliance with the requirements stipulated in this HASP is monitored by the SHSO and coordinated through the TtNUS CLEAN HSM.

Note: In some cases one person may be designated responsibilities for more than one position. For example, at NCBC Gulfport the FOL may also be responsible for the SHSO duties. This action will be performed only as credentials, experience, and availability permits.

1.2 SITE INFORMATION AND PERSONNEL ASSIGNMENTS

Site Name: Naval Construction Battalion Center **Address:** Gulfport, Mississippi

Site Point of Contact: Mr. Gordon Crane **Phone Number:** (228) 871-2485
Pager Number: (800) 343-3472

Navy Engineer-in-Charge (EIC): Mr. Arthur Conrad **Phone Number:** (843) 820-5520

Purpose of Site Visit: See Section 4.0 Scope of Work for planned activities.

Proposed Dates of Work: June 2004 - completion

Project Team:

TtNUS Management Personnel:	Discipline/Tasks Assigned:	Phone #'s/E-mail
Robert Fisher, P.E.	Task Order Manager (TOM):	(412) 921-8945 fisher@ttnus.com
Matthew M. Soltis, CIH, CSP	CLEAN Health and Safety Manager	(412) 921-8912 soltism@ttnus.com
Thomas M. Dickson, CSP	Project Health and Safety Officer (PHSO)	(412) 921-8457 dicksont@ttnus.com
TBD	Field Operations Leader (FOL)	
TBD	Site Health and Safety Officer (SHSO)	
Thomas Patton	Equipment Manager	(412) 859-4670 Fax (412) 859-0521 pattont@ttnus.com

Non-TtNUS Personnel	Affiliation/Discipline/Tasks Assigned	Phone #'s
TBD	Drilling Subcontractor	
TBD	Direct Push Drilling Subcontractor	
TBD	Land Surveying Subcontractor	

Hazard Assessment (for purposes of 29 CFR 1910.132) for HASP preparation has been conducted by:

Prepared by: Thomas M. Dickson, CSP

Shipping Address at NCBC Gulfport:

NCBC Gulfport
Building 320, Shipping and Receiving Warehouse
Attention: ________________
Tetra Tech NUS, Inc.
5200 CBC 2nd Street
Gulfport, Mississippi 39501-5000

2.0 EMERGENCY ACTION PLAN

2.1 INTRODUCTION

This section of the HASP is part of a preplanning effort to direct and guide field personnel in the event of an emergency. The first measure in accomplishing this objective is to define, what is and is not, an emergency.

An emergency as defined in 1910.120 is:

An occurrence or condition that can or has resulted in an uncontrolled release of a hazardous substance or potential safety hazard (i.e., fire, explosion, chemical exposure) associated with that release.

An incidental release as defined in 1910.120 is:

The releases of a hazardous substance that can be absorbed, neutralized, or otherwise controlled and will not result in potential safety hazard (i.e., fire, explosion, chemical exposure) are not considered emergency responses.

Based on the above definitions, TtNUS will provide through on-site resources initial incident response measures for incidents such as:

- Initial fire-fighting support and prevention
- Initial spill control and containment measures and prevention
- Removal of personnel from emergency situations
- Provision of initial medical support for injury/illness requiring only first-aid level support
- Provision of site control and security measures as necessary

Incidents and conditions above this level of participation are and will be considered emergencies. These events are considered beyond the capabilities of field personnel and above available resources to provide emergency response safely. The emergency response agencies listed in this plan are capable of providing the most effective response, and as such, will be designated as the primary responders in the event of an emergency. These agencies are located within a reasonable distance from the area of site operations, which ensures adequate emergency response time.

This Emergency Action Plan conforms to the requirements of 29 CFR 1910.38(a), as allowed in 29 CFR 1910.120(l)(1)(ii).

The FOL and/or the SHSO are responsible for this plans implementation. Any and all questions should be directed to them for clarification.

2.2 PRE-EMERGENCY PLANNING – RECOGNITION AND PREVENTION

The primary focus of this section is the ability to recognize and control factors that could contribute to an incident/emergency situation/condition. Situations/conditions recognized that could lead to an incident/emergency situation include

Physical Hazards

- Drilling activities
  - Struck by – Movement in and around operating equipment
  - Entanglement into rotating equipment
  - Contact with overhead or underground energized sources

See Section 6.2 Physical Hazards, Table 5-1 Monitoring Well Installation, and Section 9.0 Site Control for identified control measures to minimize or eliminate these hazards.

Chemical Hazards

- Groundwater sampling
  - Groundwater contamination
  - Decontamination solvents

See Section 6.1 Chemical Hazards and Tables 5-1 Mobilization/Demobilization, Monitoring Well Installation, Multi-media sampling for identified control measures to minimize or eliminate these hazards.

Natural Hazards

- Mobilization/Demobilization
- Surveying
- Multi-media Sampling
  - Snakes/Snake bite
  - Alligators

See Section 6.3 Natural Hazards and Tables 5-1 Mobilization/Demobilization, Monitoring Well Installation, Multi-media sampling, and surveying for identified control measures to minimize or eliminate these hazards.

2.2.1 General Practices – Pre-Emergency Planning

To further minimize and eliminate these potential emergency situations, emergency planning activities associated with this project, the following responsibilities are assigned to the FOL and/or the SHSO:

- The FOL and/or the SHSO will coordinate response actions with NCBC Gulfport Emergency Services personnel to ensure that TtNUS emergency action activities are compatible with facility emergency response procedures. This will serve as the initial review of the Emergency Action Plan.

- Establish and maintain information at the project staging area (Support Zone) for easy access in the event of an emergency. This information includes the following:
  - Chemical Inventory (for substances used on-site), with Material Safety Data Sheets.
  - On-site personnel medical records (medical data sheets).
  - A logbook identifying personnel on-site each day.
  - Emergency notification phone numbers in site vehicles

Note: It is the responsibility of the TtNUS FOL and/or the SHSO to ensure that this information is available and present at the site.

- Identifying a chain of command for emergency action – The FOL and/or the SHSO will serve as Incident Commander in the event of an on-site incident. He or she will remain in this position unless the incident progresses to an emergency situation. Once emergency response crews arrive he or she will relinquish command to the responding agency.

- Educating site workers - Educating site workers to the potential emergency situations that may exist and the associated control measures will be critical in early recognition and prevention. This will be accomplished through
  - Site specific training
  - Use and application of the Safe Work Permit System (See Section 10.2)
  - Daily Tool Box Meetings
  - Previewing work areas to identify, barricade, or remove physical hazards where identified.

- Survey Work Areas before committing personnel and resources - Identify, remove, and/or barricade physical hazards within the estimated work area.
  - Ensure that approach paths to monitoring wells are maintained (cleared, mowed, etc.)

- Inspect monitoring well protective casings are cleared of spider and insect nests.
- Inspect remote sample locations for signs of natural hazards (i.e., heavy brush – ticks; snakes, etc.)

- **Provide the necessary emergency action equipment** to control potential emergencies (i.e., safety cans for flammable liquid storage, spill containment equipment, PPE, and emergency equipment such as portable fire extinguishers).

- **Evaluate operations** to ensure that necessary measures are taken to control and/or minimize the impact of emergency situations/conditions. This includes actions such as, but not limited to, securing the necessary permits and clearances such as Utility and Excavation Clearances provided by the Base and Mississippi One Call Systems; Ensuring equipment and resources are at the ready for response to incidental measures; Personnel are adequately trained in the provisions of this HASP and this Emergency Action Plan.

Field Crew shall:

- Identify, remove, or barricade physical hazards within the estimated work area identified by the FOL and/or the SHSO.
- Follow the guidelines for control of emergency conditions
- Report any potential emergency situation to the FOL and/or the SHSO.

2.3 SAFE DISTANCES AND PLACES OF REFUGE/EMERGENCY ALERTING

In the event of an incident, personnel will engage identified resources necessary to prevent the condition/situation from becoming an emergency. In the event these initial response measures cannot control the incident personnel will undertake the following measures:

- Evacuate non-essential personnel to identified safe places of refuge and secure the immediate area.
- The FOL and/or the SHSO will notify emergency services
  - Give the emergency operator the location of the emergency and a brief description of what has occurred.
  - Stay on the phone and follow the instructions given by the operator.
  - The appropriate agency will be notified and dispatched.
- Field personnel will provide perimeter security of the work area until emergency services arrive.
- Once emergency services arrive TtNUS and subcontractor personnel will report to the designated safe place of refuge.

2.3.1 Critical Operations

There are no operations being conducted under this scope of work that are considered critical and would require an individual or individuals to man during an emergency. Therefore in the event of an emergency all personnel will cease all operations and report to the safe place of refuge.

2.4 DECONTAMINATION PROCEDURES/EMERGENCY MEDICAL TREATMENT

During an evacuation, decontamination procedures will be performed only if doing so does not further jeopardize the welfare of site workers. However, it is unlikely that an emergency would occur which would require workers to evacuate the site without first performing decontamination procedures. Decontamination of medical emergencies will proceed in the following manner.

2.4.1 Non-Life Threatening Medical Incident (Bruises, Cuts, Scrapes, Etc.)

The area of clothing or suit penetration will be isolated from the decontamination procedure by removing the protective garments or clothing surrounding the area of the injury and applying a light gauze wrap and plastic cover. Decontamination for unaffected areas will proceed as per Table 5-1 of this HASP.

2.4.2 Life Threatening

- Engage Emergency Notification Sequence
- Notify off-site response agencies.
- If it will not endanger the injured individual (i.e., spinal cord injury, etc.) remove any outer PPE. Removal may require the use of bandage scissors to remove the outer garments.
- Begin life saving techniques as appropriate (CPR, cooling or warming regimens, etc.).
- Cover the injured in a blanket to prevent the onset of shock.
- Follow instructions provided in Attachment I.

Note: One person from the field team will accompany the injured to the hospital with his/her medical data sheet, appropriate MSDSs (if applicable), a copy of this HASP, and the incident forms. This person will collect as much information as possible, and transfer that information to the HSM and WorkCare as per the Incident Response Protocol provided in Figure 2-1. All other personnel will engage site control/site security measures.

The SHSO upon insuring care for the injured party will engage an investigation of the incident to gather as much information as possible. This includes as a minimum answering the questions Who? What? Where? When? Why? and How?. This information will then be communicated to the PM and the HSM. Attachment I Tetra Tech NUS, Inc. Injury/Illness Procedure will be used to accomplish this task.

2.4.3 Emergency Medical Treatment

Tetra Tech NUS and subcontractor personnel are only permitted to provide treatment to the level of their First-Aid Training. It should also be noted all first aid shall be administered voluntarily. In all cases, make sure a member of the field crew notifies the emergency services and that they are enroute.

All First-Aid provided will incorporate the following protective measures:

Emergency medical treatment will be initiated under the following guarded restrictions:

- Take the necessary precautions to prevent direct contact with the injured person's body fluids. This may be accomplished through the employment of the following measures:
  - Use surgeons gloves when handling cuts, abrasions, bites, punctures, etc. or any part of the injured person. The use of safety glasses and surgeons masks is recommended, if there is the potential for uncontrolled spread of body fluids. The PHSO will be immediately notified in event that personnel providing emergency first-aid come into contact with body fluids or other potentially infectious tissues.
  - Should Cardio-Pulmonary Resuscitation (CPR) be required, use a CPR Micro-Shield mouthpiece when administering CPR to prevent contact with the injured person's body fluids.

In order to engage these protective measures the FOL shall insure that these items are part of their first-aid kit.

2.5 EMERGENCY CONTACTS

Prior to performing work at the site, all personnel will be thoroughly briefed on the emergency procedures to be followed in the event of an incident. A mobile/cellular phone shall be available on site. It will be the responsibility of the FOL and/or the SHSO to test or otherwise insure that the signal strength is sufficient to contact emergency services. If it is not then a different provider, two way radio, or other supported means of communication will be utilized. Table 2-1 provides a list of emergency contacts and their corresponding telephone numbers. This table must be posted on site where it is readily available to all site personnel or provided to site personnel.

- NCBC Contact – Mr. Gordon Crane as well as the TOM and HSM will be notified anytime outside response agencies are contacted.

TABLE 2-1
EMERGENCY REFERENCE
NCBC Gulfport

AGENCY	TELEPHONE
EMERGENCY Police Fire/Hazardous Materials Release Ambulance Services	 (228) 871-2222 (228) 871-2333 (228) 871-2444
Base Contact, Mr. Gordon Crane Pager	(228) 871-2485 1(800) 343-3472
Memorial Hospital at Gulfport 4500 13th Street Gulfport, Mississippi 39501-2569	(228) 867-4000
Task Order Manager Robert Fisher, P.E.	(850) 510-2743
CLEAN Health and Safety Manager Matthew Soltis, CIH, CSP	(412) 921-8912
Project Health and Safety Officer Thomas M. Dickson, CSP	(412) 921-8457
Utilities (On Base) (Utility Clearances and Emergencies) Public Works Maintenance Division	(228) 871-2244
Utilities (Public Utility Locating Service) Mississippi One Call System Inc.	1(800) 227-6477
Chemtrec	(800) 424-9300
National Response Center	(800) 424-8802
Mississippi Regional Poison Control Center	(800) 222-1222
Tetra Tech NUS, Tallahassee Office	(850) 359-9899
Tetra Tech NUS, Pittsburgh Office	(412) 921-7090
Tetra Tech NUS, Gulfport, Mississippi Office	(288) 575-6287

2.6 INJURY/ILLNESS REPORTING

In addition, TtNUS personnel who are injured or become ill on the job must notify appropriate company representatives. Figure 2-2 and Attachment I presents the procedure for reporting an injury/illness, and the form to use for this purpose. **If the emergency involves personnel exposures to chemicals, follow the steps in Figure 2-2.**

2.7 EMERGENCY ROUTE TO HOSPITAL

Directions from NCBC Gulfport:

From Site 4 at the intersection of 4th Street and Colby Avenue go south on Colby.

<u>Start at:</u>

Proceed south on Colby Ave. to Engram Drive

Turn Left on Engram Drive. Proceed due east to Braod Ave..

Turn Right on Broad Avenue.

Turn Left on 13th Street

<u>End at:</u>

Memorial Hospital at Gulfport
4500 13th Street
Gulfport, Mississippi 39501-2569

Figure 2-1
Route to Hospital

FIGURE 2-2
EMERGENCY RESPONSE PROTOCOL

The purpose of this protocol is to provide guidance for the medical management of injury situations.

In the event of a personnel injury or accident:

- Rescue, when necessary, employing proper equipment and methods.
- Give attention to emergency health problems -- breathing, cardiac function, bleeding, and shock.
- Transfer the victim to the medical facility designated in this HASP by suitable and appropriate conveyance (i.e. ambulance for serious events)
- Obtain as much exposure history as possible (a Potential Exposure report is attached).
- If the injured person is a Tetra Tech NUS employee, call the medical facility and advise them that the patient(s) is/are being sent and that they can anticipate a call from the WorkCare physician. WorkCare will contact the medical facility and request specific testing which may be appropriate. WorkCare physicians will monitor the care of the victim. Site officers and personnel should not attempt to get this information, as this activity leads to confusion and misunderstanding.
- Call WorkCare at 1-800-455-6155 and enter Extension 109, or follow the voice prompt for after hours and weekend notification and be prepared to provide:
  - Any known information about the nature of the injury.
  - As much of the exposure history as was feasible to determine in the time allowed.
  - Name and phone number of the medical facility to which the victim(s) has/have been taken.
  - Name(s) of the involved Tetra Tech NUS, Inc. employee(s).
  - Name and phone number of an informed site officer who will be responsible for further investigations.
  - Fax appropriate information to WorkCare at (714) 456-2154.
- Contact Corporate Health and Safety Department (Matt Soltis) and Human Resources Manager Marilyn Duffy at 1-800-245-2730.
- As data is gathered and the scenario becomes more clearly defined, this information should be forwarded to WorkCare.

WorkCare will compile the results of the data and provide a summary report of the incident. A copy of this report will be placed in each victim's medical file in addition to being distributed to appropriately designated company officials.

Each involved worker will receive a letter describing the incident but deleting any personal or individual comments. A personalized letter describing the individual findings/results will accompany this generalized summary. A copy of the personal letter will be filed in the continuing medical file maintained by WorkCare.

FIGURE 2-2 (continued)
WORKCARE
POTENTIAL EXPOSURE REPORT

Name: ______________________ Date of Exposure: ____________

Social Security No.: ______________ Age: ________ Sex: ______

Client Contact: ______________________ Phone No.: ____________

Company Name: ____

I. Exposing Agent
Name of Product or Chemicals (if known): ______________________
____
Characteristics (if the name is not known)
Solid Liquid Gas Fume Mist Vapor

II. Dose Determinants
What was individual doing? ______________________
How long did individual work in area before signs/symptoms developed? ____________
Was protective gear being used? If yes, what was the PPE? ____________
Was their skin contact? ______________________
Was the exposing agent inhaled? ______________________
Were other persons exposed? If yes, did they experience symptoms? ____________

III. Signs and Symptoms (check off appropriate symptoms)

Immediately With Exposure:

Burning of eyes, nose, or throat
Tearing
Headache
Cough
Shortness of Breath
Chest Tightness / Pressure
Nausea / Vomiting
Dizziness
Weakness

Delayed Symptoms:

Weakness
Nausea / Vomiting
Shortness of Breath
Cough
Loss of Appetite
Abdominal Pain
Headache
Numbness / Tingling

IV. Present Status of Symptoms (check off appropriate symptoms)
Burning of eyes, nose, or throat
Tearing
Headache
Cough
Shortness of Breath
Chest Tightness / Pressure
Cyanosis
Nausea / Vomiting
Dizziness
Weakness
Loss of Appetite
Abdominal Pain
Numbness / Tingling

Have symptoms: (please check off appropriate response and give duration of symptoms)
Improved: ________ Worsened: ______ Remained Unchanged: ______

V. Treatment of Symptoms (check off appropriate response)
None: ________ Self-Medicated: ______ Physician Treated: ______

3.0 SITE BACKGROUND

3.1 SITE DESCRIPTION

The Naval Construction Battalion Center (NCBC) Gulfport, Mississippi was commissioned as the homeport of the Atlantic Fleet Seabees in 1966. The Base occupies approximately 1,100 acres in the western part of Gulfport in the southeastern coastal area of Mississippi. The Navy previously used the property as a Naval Training Center and Naval Storehouse starting in 1942. Presently, four Naval Mobile Construction Battalions (NMCB) are based at Gulfport.

3.2 SITE LOCATION AND HISTORY

Site 4 is a former 4.0 acre landfill located northeast of the intersection of 7th Street and Colby Avenue and is adjacent to the driving range at the Pine Bayou Golf Course (See Figure 2-2 of the Work Plan). As shown on Figure 2-2, the northern boundary of the landfill is adjacent to Canal No. 1. The landfill was operated from 1966 until 1972 and was the only operating landfill on the base at that time. Waste material was disposed of in trenches, burned daily, and then backfilled. Most, if not all, of the solid waste and some of the liquid and chemical waste generated at the installation were disposed of at Site 4 during the period of landfill operation (Initial Assessment Study, Envirodyne Engineers, Inc., 1985).

4.0 SCOPE OF WORK

This section discusses the specific tasks that are to be conducted as part of this scope of work as identified by CTO 0283. These tasks are the only ones addressed by this HASP. Any tasks to be conducted outside of the elements listed here will be considered a change in scope requiring modification of this document. The TOM or a designated representative will submit the requested modifications to this document to the HSM.

Specific tasks to be conducted include, but are not necessarily limited to, the following:

- Mobilization/demobilization activities
- Soil borings via Direct Push Technology (DPT)
  - 10 soil borings will be conducted at Site 4. Samples will be sent for chemical analysis.
  - 3 locations will be sent for geotechnical analysis
  - Undetermined number of subsurface soil samples will be collected adjacent to primary geophysical anaomalies.
- Monitoring well installation using HSA - 5 new monitoring wells are to be installed (3 shallow, 2 deep)
- Multi-media Sampling
  - Surface water sampling
  - Sediment sampling – 3 co-located surface water sediment samples will be collected from Canal No.1.
  - Monitoring well development and groundwater sampling
    - o 15 DPT groundwater samples will be collected in the plume area using peristaltic pumps. VOC analysis.
    - o 10 DPT groundwater samples will be collected from the soil boring locations using peristaltic pumps. Full suite analysis with Natural Attenuation sampling.
    - o 8 Existing monitoring wells using Redi-Flo pumps Full suite analysis with dioxins/furans with Natural Attenuation sampling.
    - o 5 newly installed monitoring wells using Redi-Flo pumps Full suite analysis with dioxins/furans with Natural Attenuation sampling.
  - Subsurface Soil sampling – See Soil borings above.
- Decontamination
- Geophysical/Geographic Surveying
- IDW Management

For more detailed description of the associated tasks, refer to the Work Plan (WP).

5.0 TASKS/HAZARDS/ASSOCIATED CONTROL MEASURES SUMMARIZATION

Table 5-1 of this section is intended to assist project personnel in the recognition of hazards and recommended control measures necessary for each planned task to minimize potential exposure or injuries related to those hazards. The table also assists field team members in determining which personal protective equipment (PPE) and decontamination procedures are to be used as well as appropriate air monitoring techniques and action levels. This table must be updated if the scope of work, contaminants of concern, or pertinent conditions change.

Safe Work Permits will be issued for all site activities (See Section 10.2). The FOL and/or the SHSO will use the elements defined in Table 5-1 as the primary reference for completing the Safe Work Permit adding additional information as warranted.

The following text provides a general description of the tasks to be conducted and are the basis for the hazard assessment.

5.1 MOBILIZATION/DEMOBILIZATION

This task includes, but not limited to, the following

- The procurement and shipping of equipment, and materials for the field investigation.
- Review of planning documents (i.e., HASP, Sampling and Analysis Plan, Work Plan, Quality Assurance Plan, etc.)
- Site Reconnaissance to include site characterization, site preparation, the layout of sampling locations, securing the necessary utility clearances and isolate physical hazards, where applicable.
- Secure, construct, or equip decontamination facilities to support the field activities.
- Secure, construct, or equip IDW storage facilities to support the field activities.

Physical Hazards – The hazard types associated with this task are considered primarily to be Physical hazards – Lifting, strains/sprains, lacerations achieved during unpacking of equipment and during site preparation (i.e., cutting open boxes, lifting equipment, locating sample points).

Chemical Hazards - It is not anticipated that personnel will be exposed to chemical hazards during this task. The FOL and/or the SHSO must establish the site-specific Hazard Communications Program to address potential chemical hazards of chemicals brought on-site. See Section 5.0 of the HSGM.

5.2 MONITORING WELL INSTALLATION – HOLLOW STEM AUGER

Five wells are to be installed at Site 4 including 3 shallow wells and 2 deep wells as part of this field effort using Hollow Stem Auger techniques. This method of drilling consists of advancing hollow rotating augers into the ground. Cuttings are brought to the surface by the rotating action of the auger. Advantages of this type of drilling include:

- Samples can be obtained while augers remain in the ground. Sampling requires the use of split-barrel or thin-wall tube samplers advanced through the hollow core of the auger.
- No drilling fluids are required.
- A well can be installed inside the auger stem and back-filled as the augers are withdrawn.

Physical Hazards – Physical hazards includes

- Entanglement within rotating equipment (augers); caught between pinches and compressions. These hazards are not only the most serious (entanglement) but also pinches/compressions are the most frequent in the drilling industry. Due to a recent fatality due to entanglement several safe work practices have been incorporated into this activity. These include

    - All emergency stop devices will be tested initially and periodically thereafter. This will be accomplished during the equipment inspection and at random intervals.
    - One person on the drill crew will be designated as the Emergency Stop Device Operator.
    - Prior to the initiation of augers, the driller will announce they are about to start and will insure all personnel are away from rotating apparatus.
    - The SHSO shall insure that all personnel have
        - Secured/removed all loose clothing articles
        - Removed all jewelry that could snag

- Energized Systems – Overhead and underground.

- Lifting – auger flights (>100 lbs) bags of Portland Cement (>90 lbs). Again this is a very common occurrence within the drilling industry.

- Pressurized systems – This hazard is compounded due to the workers close proximity to pressurized hydraulic lines and systems on the drill rigs. In addition, pressurized hazards exist as it pertains to the decontamination process. In addition, the potential for burns or water lacerations exists during the decontamination process of auger flights and drill equipment when using pressurized and/or steam cleaners. There was an incident that occurred within the last two years in which a pressurized linebroke free and struck a driller resulting in a near fatality. Therefore, extra efforts will be employed to insure that fittings and connections are secure. Those fittings and connections near the operator or drillers helper that are not guarded will be secured by whatever means are necessary (i.e., pressurized line restraints).

- Traffic hazards – This site are located within very active golf course. The primary investigation area separates the Driving Range and the 1st Tee Box. Both foot and vehicular traffic hazards are considered prevalent during certain phases of executing this scope of work.

- Noise – The operating level of a standard hollow stem auger drill rig varies between 86 and 89 dBA's presenting potential noise exposure concerns. This potential hazard is also a concern during the decontamination process using pressure washer/steam cleaners. These items typically operate at 94-97 dBA when engaged.

- Cuts, pricks, and lacerations – This hazard is possible when cutting tubing or when opening some of the glass reagent ampoules. In addition when transporting glassware for sample collection or testing may present a problem should the glassware become broken

Chemical Hazards – Potential occupational chemical exposure during this activity would be anticipated under the following conditions.

- Contaminant exposure based on direct interaction with contaminated media. See Table 5-2 for potential health effect information.

- Exposure to chemicals associated with well construction materials are also a concern. This includes sand, grout and cement (both containing Portland Cement), and Bentonite. Hazards associated with these chemicals include irritation of the eyes, alkali/chromium burns of contact points associated with wet cement, and respiratory irritation.

See Site specific Hazard Communication Program for control measures facilitated through creating and maintaining and accurate chemical inventory, employee training, proper container labeling, and MSDS use.

5.3 AQUIFER DEVELOPMENT/TESTING/SAMPLING

5.3.1 Monitoring Well Development

The development of the monitoring wells are intended to remove debris associated with installation and to condition the sand pack to facilitate contact with the surrounding aquifer. Monitoring well development is typically accomplished using surge blocks and pumps to force water in and out of the sand pack and formation and to remove this debris from the well. 1" inch Whale Pumps with 12-volt battery will be employed to remove specified water volumes as well as any debris. The wells to be developed include the 5 newly installed and any existing wells that have not been sampled within the last two years.

See Section 5.3.4 for potential hazards.

5.3.2 Permanent/Temporary Monitoring Well Sampling

The monitoring wells will be sampled using low-flow purging and sampling techniques. Redi-Flo pumps will be used to purge and to collect the samples. Field measurements of pH, temperature, specific conductance, and turbidity will be made during purging using a direct reading instrument. These measurements will be taken at the start of purging and every 5 to 15 minutes until the parameters have stabilized. The wells will be purged until a sufficient predetermined amount of water has been removed and the water quality measurements are acceptable and stable. All tubing used for sampling will be dedicated and disposed of after the sample has been collected.

5.3.2.1 Natural Attenuation Sampling

As part of the sampling effort sample aliquots will be remove once the sample that will be sent for chemical analysis has been collected. These sample aliquots will be subjected to a number of field tests to determine the natural degradation of the contaminant in question as well as the conditions which may support or retard this process. This process for the most part requires the addition of reagents to the sample. The reaction between the sample and the reagent will produce possibly a color change or other indicator identified.

5.3.3 Water Level Measurements

Water level measurements will be taken at the existing and newly installed temporary monitoring wells during this field investigation. The water levels will be taken with an electric water level indicator using the top of the well casing as the reference point for determining water depths. Water levels will be conducted upon completion of the newly installed wells and prior to and through the course of purging and sampling.

For those wells at Site M-13 the water level measurements will be conducted as close as possible at high tide, then again at low tide.

5.3.4 Hydraulic Conductivity Testing

Hydraulic characteristics of the groundwater will be tested to determine the ability of the porous material surrounding the well to transmit water. This information will be employed to evaluate flow patterns as well as contaminant migration to construct a model for the area of investigation. Currently, it is planned that at each site each of the newly installed wells will be slug tested as well as four existing wells.

Slug testing is comprised of rising and falling tests. A pressure transducer is placed in the well, and a slug (of known volume) is either introduced (falling head test) into the water column or extracted (rising head test) from the water column. The pressure transducer measurements the changes in water level or an increment of time.

Physical Hazards – The hazard types associated with the above tasks are similar in nature and therefore presented together. Physical hazards as it pertains to development, sampling, hydraulic conductivity testing –

- Lifting, strains/sprains, associated with handling purge/development waters.

- Cuts, pricks, and lacerations – This hazard is possible when cutting tubing or when opening some of the glass reagent ampoules. In addition when transporting glassware for sample collection or testing may present a problem should the glassware become broken

- Traffic hazards – These sites are located within very active industrial areas. Some of the investigation locations are in the middle of travel thoroughfares. Both foot and vehicular traffic hazards are considered prevalent during certain phases of executing this scope of work.

- Electrical hazards – Remote but possible when handling and using a 12-volt battery as a power source for the Whale pumps (used in development) or for the Redi-Flo pumps.

Chemical Hazards - Chemical exposure during this activity maybe facilitated through

- Direct contact - Splash - Contaminant exposure based on direct interaction with contaminated media through possible splash.

- Inhalation – Some wells due to biological degradation may build off-gases. When a field crew member opens the well they maybe exposed to vapors/gases coming out of the well as well as be exposed to the pressure related hazard. To control exposure we limit the proximity of the technician to the well head as well as the amount of time he or she remains there.

- Ingestion – Due to handling of equipment, sample media, and improper work hygiene could result in the ingestion of identified site contaminants.

- Sample preservatives/natural attenuation reagents/decontamination solutions – Certain chemicals will be brought on-site in support of this field investigation effort. These chemical hazard classes include corrosives, flammable, and oxidizers.

See Table 5-2 for potential health effect information due to chemical exposure. See also the Site Specific Hazard Communication Program for controlling hazards as it pertains to chemical substances brought on-site.

5.4 MULTI-MEDIA SAMPLING

5.4.1 <u>Surface and Subsurface Soil Samples</u>

A total of 10 subsurface soils samples will be collected at Site 4. The subsurface soil samples will be collected from ground surface to an estimated 40-feet bgs. Samples will be collected in acetate tubes 12-inches in length. The top 3-inches will be removed and placed in a plastic bag where after 20-minutes a headspace measurement will be collected. The interval showing the highest headspace measurement will be sent for analysis. Four samples will be collected from within the plume area. Additional samples are planned for near geophysical anomalies. Three samples will be sent for geotechnical analysis.

Physical Hazards – The hazard types associated with the above tasks include

- Cuts and lacerations – This hazard is possible when cutting the acetate liners. Hazards of this nature can be prevented using Geoprobe Kits or similar devices to secure the liners while cutting.

5.5 GEOGRAPHICAL/GEOPHYSICAL SURVEYING

This activity is generally non-intrusive in nature. Vertical elevations and horizontal locations will be taken from the ground surface at well and soil sampling locations.

Physical Hazards associated with this task includes

- Traffic hazards – These sites are located within very active industrial areas. Some of the investigation locations are in the middle of travel thoroughfares. Both foot and vehicular traffic hazards are considered prevalent during certain phases of executing this scope of work.

- Trips and Falls – This hazard is considered due to uneven ground (curb sides, hill sides) and potentially slippery surfaces.

Natural Hazards – This hazard is considered prevalent during as this activity as the locations are remote and not regularly maintained. However, the possibility exists. In addition, many recordable injuries within the past years have been related to this type of hazard and therefore worth mentioning.

5.6 DECONTAMINATION

The equipment involved in the field activities for well installation and sampling will be decontaminated prior to, during and after the completion of on-site activities.

5.6.1 Heavy Equipment

Heavy equipment decontamination will be accomplished using a pressure washer and/or steam cleaner within an established temporary decontamination pad.
Procedural steps are as follows

1. Remove gross (visible) materials using scrapers, shovels as necessary (soils, etc.)
2. Use the pressure washer/steam cleaner remove remaining visible debris.
3. As necessary, follow up with scrub brushes with Alconox or Liquinox detergent wash.
4. Potable water rinse using pressure washer/steam cleaner as necessary
5. Solvent rinse (Isopropanol) – This application will only pertain to the sample collecting media (split spoon, reusable trowels and hand augers, See 5.6.2).
6. DI water rinse
7. Air dry

5.6.2 Sampling Equipment

All non-dedicated sampling equipment (i.e. stainless-steel hand augers, trowels, bowls) will be decontaminated prior to the initiation of field sampling, between sample locations, and at the completion of the field activities. The following decontamination steps will be taken.

1. Remove heavy materials (soils, etc.)
2. Alconox or Liquinox detergent wash
3. Potable water rinse
4. Solvent rinse (Isopropanol)
5. DI water rinse
6. Air dry

All dedicated sampling and PPE equipment will be rinse to remove gross contamination and then disposed of.

Physical Hazards associated with this activity include

- Water cuts/lacerations/burns – This is the primary and most severe hazard associated with this activity. Incidents have occurred where persons have placed the pressure wand on their boot and accidentally compressed the trigger resulting in burns and water lacerations.

- Noise – Operating level of the pressure washer/steam cleaners typically operate at 94-97 dBA when engaged.

Chemical Hazards associated with this activity include

- Exposure to contaminated media
- Exposure to decontamination solvents

5.7 INVESTIGATIVE DERIVED WASTE MANAGEMENT

This task includes the containerization, labeling, staging, monitoring, and final deposition of investigative derived wastes. These are as follows:

Containerization – Materials generated including soils, purge and development waters, decontamination fluids shall be collected and containerized in 55-gallon drums and staged in a centralized location at the trailer yard.

Labeling – All containers will be labeled as to their contents. The labels will include the following information

Site
Job Number
Location (SWMU)
Date – To be completed once filling the container begins
Drum # - Assign an inventory number to be added to a comprehensive log
Contents – Description
Volume – Final volume
Contact – This person should be available on base. To this end an up-dated inventory should be provided at the close of each shift to this person.
Emergency Number – Contact person provided above

Staging – All drums will be staged on pallets (4 to a pallet) with lid retention ring bolt accessible on the outside as well as the label. Pallet rows will maintain a minimum of 4 feet between rows for access and monitoring for leaks. Containers will be separated according to media and site.

Monitoring – During staging site personnel will examine containers to ensure they are not leaking.

Final Deposition – Waste materials will be separated as determined through sampling and disposed of through pre-determined routes.

Physical Hazards associated with this Waste Management activity include

- Caught between pinches and compressions. This occurs primarily when moving containers to transport vehicles and when staging the drums on pallets. The prevalent hazard is recognized when moving the drums and hands get caught between drums.

- Lifting – Drums of water can weigh upwards of 475 lbs. Drums of wet soil can weigh up to 750 lbs.

For more detailed description of the associated tasks, refer to the Work Plan (WP) and/or the Quality Assurance Plan (QAP).

5.8 GENERAL SAFE WORK PRACTICES

In addition to the task-specific safe work practices identified in Table 5-1 to be employed to minimize task specific hazards, the following general safe work practices will be observed. These safe work practices establish a pattern of general precautions and measures for reducing risks associated with hazardous site operations.

- Refrain from eating, drinking, chewing gum or tobacco, taking medication, or smoking in contaminated or potentially contaminated areas or where the possibility for the transfer of contamination exists.
- Wash hands and face thoroughly upon leaving a contaminated or suspected contaminated area. This is especially critical between breaks and prior to lunch and associated hand to mouth activities.
- Avoid contact with potentially contaminated substances by walking around puddles, pools, mud, or other such areas. Avoid, whenever possible, kneeling on the ground or leaning or sitting on equipment. Do not place monitoring equipment on potentially contaminated surfaces.
- Be familiar with and adhere to all instructions provided within this site-specific HASP.
- Be aware of the location of the nearest telephone and all emergency telephone numbers. See Section 2.0, Table 2-1.
- Attend briefings on anticipated hazards, equipment requirements, Safe Work Permits, emergency procedures, and communication methods before going on site.
- Plan and mark entrance, exit, and emergency escape routes. See Section 2.0.
- Rehearse unfamiliar operations prior to implementation.
- Use the “buddy system”.
- Maintain visual contact with each other and with other on-site team members by remaining in close proximity in order to assist each other in case of emergency.

- Establish appropriate Safety Zones including Support, Contamination Reduction, and Exclusion Zones.
- Minimize the number of personnel and equipment in contaminated areas (such as the Exclusion Zone). Non-essential vehicles and equipment should remain within the Support Zone.
- Establish appropriate decontamination procedures for leaving the site.
- Immediately report all injuries, illnesses, and unsafe conditions, practices, and equipment to the Site Health and Safety Officer (SHSO).
- Matches and lighters are restricted from entering in the Exclusion Zone or Contamination Reduction Zone. Smoking will only be permitted in specified areas at Site 4.
- Observe coworkers for signs of toxic exposure and heat or cold stress.
- Inform co-workers of potential symptoms of illness, such as headaches, dizziness, nausea, or blurred vision.

5.9 DRILLING (HSA/DPT) SAFE WORK PRACTICES

The following Safe Work Practices are to be followed when working in or around the HSA Drill Rig Operations.

5.9.1 Before Drilling

- Identify all underground utilities and buried structures before drilling. This service is provided by the NCBC Gulfport. In addition, Tetra Tech NUS, Inc. personnel will use the Utility Locating and Excavation Clearance Standard Operating Procedure provided in Attachment II.
- All drill rigs will be inspected by the SHSO or designee, prior to the acceptance of the equipment at the site and prior to the use of the equipment. All repairs or deficiencies identified will be corrected prior to use. The inspection will be accomplished using the Equipment Inspection Checklist for Drill Rigs provided in Attachment III. Additional inspections will be performed at least once every 10-day shift or following repairs.
- Check operation of the Kill Switch (initially, then weekly).
- Insure all machine guarding is in place and properly adjusted.
- Block drill rig and use levelers to prevent movement of the drill.

- The work area around the point of operation will be graded to the extent possible to remove any trip hazards near or surrounding operating equipment.

- The drillers helper will establish an equipment staging and laydown plan. The purpose of this is to keep the work area clear of clutter and slips, trips, and fall hazards. Mechanisms to secure heavy objects such as drill flights will be provided to avoid the collapse of stacked equipment.

- All potentially contaminated tooling will be wrapped in polyethylene sheeting for storage and transport to the centrally located equipment decontamination unit.

5.9.2 During Drilling

- Minimize contact to the extent possible with contaminated tooling and environmental media.

- Support functions (sampling and screening stations) will be maintained a minimum distance from the drill rig of the height of the mast plus five feet to remove these activities from within physical hazard boundaries. These boundaries because they are in areas where the general population exists will be strictly enforced by site personnel.

- Only qualified operators and knowledgeable ground crew personnel will participate in the operation of the drill rig.

- During maintenance, use only manufacturer provided/approved equipment (i.e. auger flight connectors, etc.)

- In order to minimize contact with potentially contaminated tooling and media and to minimize lifting hazards, multiple personnel should move auger flights and other heavy tooling.

- Only personnel absolutely essential to the work activity will be allowed in the exclusion zone. Site visitors will be escorted at all times.

5.9.3 After Drilling

- All equipment used within the exclusion zone will undergo a complete decontamination and evaluation by the SHSO to determine cleanliness prior to moving to the next location, exiting the site, or prior to down time for maintenance.

- All motorized equipment will be fueled prior to the commencement of the days activities. During fueling operations all equipment will be shutdown and bonded to the fuel source.

TABLE 5-1
TASKS/HAZARDS/CONTROL MEASURES NCBC GULFPORT, GULFPORT, MISSISSIPPI

Task/Operation/Location	Anticipated Hazards	Recommended Control Measures	Hazard Monitoring - Types and Action Levels	Personal Protective Equipment *(Items in italics are deemed optional as conditions or the FOL or SHSO dictate.)*	Decontamination Procedures
Mobilization/Demobilization This activity includes, but not limited to: - Equipment Preparation and Inspection - Resource acquisition and unpacking of supplies - Site clearance and preparation – Utility clearances, etc. - Establish and construct access routes to sample/work locations, where applicable. - Construct decontamination and IDW operation and storage facilities, as applicable.	***Chemical hazards:*** 1) Exposure to identified site contaminants are not anticipated. However, potential exposure to chemicals brought on-site should be considered. ***Physical hazards:*** 2) Lifting (strain/muscle pulls) 3) Cuts and lacerations 4) Pinches and compressions/Struck by 5) Slips, trips, and falls 6) Heavy equipment hazards (swinging booms, hydraulic lines, etc.) 7) Vehicular and foot traffic ***Natural hazards:*** 8) Ambient temperature extremes (heat/cold stress) 9) Insect and animal bites 10) Inclement weather	***Chemical hazards:*** 1) The on-site Hazard Communication Program (Section 5.0 TtNUS Health and Safety Guidance Manual) will be followed. All chemicals brought onto the site by Tetra Tech NUS and subcontractor personnel will be inventoried with each applicable chemical having an MSDS on site, on file. This effort shall include • Accurate Chemical Inventory List (Entries will match chemicals brought on-site, as the names appear on the MSDS and the label) This list, which also includes quantities and storage locations will be maintained in a centralized location and made available upon request. • MSDS's will be maintained in a central location, accessible to all personnel. • All containers will have labels specifying the following information: - Chemical Identity (As it appears on the label, MSDS, and Chemical Inventory List) - Appropriate Warning (i.e., Eye and skin irritation, flammable, etc.) - Manufacturer's Name Address and Phone Number All personnel will be required to review the appropriate MSDS's if they are not familiar with the hazards of the chemicals to be used, prior to the use of a specified chemical substance. Information on hazards and PPE will be communicated on the Safe Work Permit for this task. Any specific provisions recommended by the MSDS shall be in place (i.e., eye wash, fire extinguisher, specified PPE, etc.) prior to using the chemical substance. ***Physical hazards:*** 2) **Lifting Hazards** – During mobilization/demobilization personnel are required to handle equipment, supplies, and resources in preparation for site activities. This hazard becomes more predominant in the early morning hours (prior to muscles becoming limber) and later in the day (as a result of fatigue). The following provisions shall be instituted in order to minimize hazards of this nature: • Use machinery or multiple personnel for heavy lifts, where possible. • Use proper lifting techniques - Lift with your legs, not your back, bend your knees move as close to the load as possible, and ensure good hand holds are obtainable. - Minimize the horizontal distance to the center of the lift to your center of gravity. - Minimize turning and twisting when lifting as the lower back is especially vulnerable at this time. - Break lifts into steps if the vertical distance (from the start point to the placement of the lift) is excessive. - Plan your lifts – Place heavy items on shelves between the waist and chest; lighter items on higher shelves. - Periods of high frequency lifts or extended duration lifts should provide sufficient breaks to guard against fatigue and injury. Other considerations associated with lifting injuries and muscle strains include • Area available to maneuver the lift. • Area of the lift – Work place clutter, slippery surfaces • Your Overall physical condition 3) **Cuts and lacerations** – To prevent cuts and lacerations associated with unpacking or packing equipment and supplies, during site preparation (clearing access routes), the following provisions are required: - Always cut away from yourself and others, then, if a knife slips, you will not impale yourself or others. - Do not place items to be cut in your hand or on your knee. - Change out blades as necessary to maintain a sharp cutting edge. Many accidents result from struggling with dull cutting instruments. If hand tools (brush hooks, machetes, etc.) are used to gain access to sample locations, the following precautions are recommended: - Insure handles are of good construction (no cracks, splinters, loose heads/cutting apparatus. - Insure all cutting tools are maintained. Blades shall be sharp without knicks and gouges in the blade. - All hand tools (brush hooks, machetes, etc.) with cutting blades shall be provided with a sheath to protect individuals when not in use and when carrying these items over rough or slippery terrain. - All personnel will maintain a 10-foot perimeter or greater around persons clearing brush and access paths to sample and/or well locations. 4) **Pinches/Compressions/Struck By** - Do not modify tooling without manufacturer's expressed permission. - Keep any machine guarding in place, avoid moving parts. - Use tools or equipment where necessary to avoid placing hands in areas vulnerable to pinch points. - Adjust machine guarding as necessary to minimize distance between guards and point of operation. - When staging equipment, insure all stacked loads, shelving, are adequately secure to avoid creating a hazard from falling objects. 5) **Preview work locations for unstable/uneven terrain**. - Cover, guard and barricade all open pits, ditches, and floor opening as necessary. - Ruts, roots, tools, and other tripping hazards should be eliminated to minimize trips and falls. - Maintain a clutter free work area. - As part of site control efforts construct fences or other means of demarcation (i.e. signs and postings) to control and isolate traffic in the work area. Means of demarcation shall also be constructed isolating resource and/or staging areas. - Work areas greater than 6-feet above ground surface shall employ acceptable engineered fall protection (i.e. handrails and platforms) or accepted fall protection harnesses. 6) **Heavy Equipment Hazards** - All equipment will be - Inspected in accordance with OSHA and manufacturer's design. - All equipment inspection will be documented on a Equipment Inspection Checklist as provided in (See Attachment III). - Operated by knowledgeable operators and ground crew. 7) **Vehicular and Foot Traffic Hazards** - As part of site preparation activities and zone construction, when preparing traffic and equipment considerations are to include the following: - Establish safe zones of approach (i.e. Boom or mast + 5 feet). - The mast will be lower when moving the rig. - Foot and vehicular traffic routes shall be well defined. - Heavy equipment patterns shall be isolated using fences or other suitable barricades from pedestrian pathways. - Bumpers or other suitable traffic stops shall be placed in areas where it is desired that traffic approaching an drop offs or unprotected banks. - All self-propelled equipment with restricted vision moving backwards shall be equipped with back up warning systems. - The FOL and/or the SHSO as a precautionary measure to remove or demarcate physical hazards shall preview traffic routes (foot and vehicular) before the commitment of personnel and resources. ***Natural hazards:*** 8) **Ambient Temperature Extremes** - Wear appropriate clothing for weather conditions. Provide acceptable shelter and liquids for field crews. Additional information regarding heat and cold stress is provided in Section 4.0 of the TtNUS Health and Safety Guidance Manual. 9) **Insect/Animal Bites and Stings** - This is not considered a predominant hazard as these activities are to be conducted in a well maintained area between the driving range and first tee box. To combat the potential impact of natural hazards, the following actions are recommended Snakes – The potential for encountering snakes is more likely near waters edge and along the bank where they sun themselves - Items laying on the ground provide cover and nesting locations. If you must pick something up to move it always pull it towards your body to provide a shield. - Well pads often provide preferred sunning areas for snakes - Leave snakes and animals alone, do not harass or try to capture. Contact the SHSO for direction in the removal of animals and snakes within the confines of the work site. - Snake chaps or high leather boots should be worn in unimproved or unmaintained areas, if you are unknowledgeable regarding nesting and habitat considerations for indigenous animals and reptiles. - Keep hands and feet out of areas you cannot see. Alligators – Again may present a hazard along the Northern Canal (waters edge) - Do not harass or otherwise bother an alligator - Remember they are more aggressive during mating and nesting periods.	Visual observation of work practices by the FOL and/or the SHSO to minimize potential physical hazards (i.e., improper lifting, unsecured loads, cutting practices, etc.). Monitoring for chemical hazards are not required during this activity.	Level D - (Minimum Requirements) - Standard field attire (Sleeved shirt; long pants) - Safety shoes (Steel toe/shank) - *Snake chaps (for remote and unmaintained areas)* - *Safety glasses (for moving through brush and when involved in activities that could result in flying projectiles such as hammering or chopping and clearing brush)* - *Hardhat (when overhead hazards exists, or identified as a operation requirement)* - *Reflective vest for high traffic areas* - *Hearing protection for high noise areas (At the direction of the FOL and/or the SHSO).* As site conditions may change, the following equipment will be maintained during all on-site activities as prescribed in Section 2.0 of this HASP - Fire Extinguishers - First-aid kit ***Note:*** *The FOL and/or the SHSO will determine the number of fire extinguishers and first-aid kits to be made available based on the number of operations to be conducted at any given time.*	Not required. Good personal hygiene practices should be employed prior to breaks lunch or other period when hand to mouth contact occurs. This will minimize potential ingestion exposures. Site Preparation – A structured decontamination is not required for this activity. However, as some site preparation activities may require personnel to enter unimproved areas (heavy underbrush wooded areas) personnel should inspect themselves and one another for the presence of ticks when exiting wooded areas, grassy fields, etc. This action will be employed to assist in stopping the transfer of these insects into vehicles, homes, and offices. In a review of a number of tick bites reported over the past few years, the ticks that went undetected were located on the back and in the shoulder areas. Have your buddy examine this area carefully.

		- Buddy System – Always use two people when performing duties in areas where alligators may exist. One to serve as a watch while the other completes the sampling. - Remote sampling devices – Use remote sampling devices such as extended poles, dredges etc. for sediment and surface waters to remove personnel from the water or waters edge. - Boats – Where possible use a boat to isolate yourself from their environment. It is never recommended that waders be employed in alligator infested waters. - Nesting areas – These areas are usually marked by mounded areas of grasses and mud. A telltale characteristic of these nests is the noticeable slide marks leading from the mound into the water. Avoid these areas. Insects and spiders - Wear light color clothes. This will allow easier detection of ticks and insects crawling on your body. It will also assist in heat stress control. - Tape pant legs to work boots to block direct access. This is especially critical when clearing or entering heavy brush and wooded areas. - Do not stick your hand anywhere where you can't see. - When opening existing well heads be cautious of bees and spiders as these are preferred nesting locations. - Use repellents – Follow manufacturer's recommendations for use. Permanone should be applied liberally to the clothing, but not the skin as it may cause irritation. Concentrate on areas where ticks and other insects may access your body such as pant cuffs, shirt to pants, and collars. - If you leave your workboots at the trailer or office over your break make sure you shake them out before sticking your feet in them. See Section 4.0 of the HSGM for more information concerning these natural hazards. 10) **Inclement Weather** - Suspend or terminate operations until directed otherwise by SHSO. See Section 4.0 of the TtNUS Health and Safety Guidance Manual for additional information concerning natural hazards.			

TABLE 5-1
TASKS/HAZARDS/CONTROL MEASURES NCBC GULFPORT, GULFPORT, MISSISSIPPI

Task/Operation/Location	Anticipated Hazards	Recommended Control Measures	Hazard Monitoring - Type and Action Levels	Personal Protective Equipment *(Items in italics are deemed optional as conditions or the FOL or SHSO dictate.)*	Decontamination Procedures
Monitoring Well Installation/Soil Borings Five monitoring wells will be installed at Site 4 (3 shallow, 2 deep) as part of this field effort using 10 subsurface soil samples will be collected at Site 4.	***Chemical hazards:*** 1) Previous analytical data identified the following compounds as contaminants of concern Site 4 Vinyl chloride (VC) 37µg/L (ppb) GPT-4-5 Further information on these contaminants are presented in Section 6.1 and Table 6-1. 2) Transfer of contamination into clean areas or onto persons ***Physical hazards:*** 3) Heavy equipment hazards (pinch/compressions points, rotating equipment, hydraulic lines, etc.) 4) Noise in excess of 85 dBA 5) Energized systems (contact with underground or overhead utilities) 6) Lifting (strain/muscle pulls) 7) Slips, trips, and falls 8) Cuts and lacerations 9) Vehicular and foot traffic Further information on these physical hazards, see Section 6.2 for further discussions. ***Natural hazards:*** 10) Inclement weather 11) Insect bites	***Chemical hazards:*** 1) Safe work practices and monitoring instruments will be employed as the first line of defense. As a general rule, avoiding contact with contaminated media (water, soils, etc.). In addition, good work hygiene practices including avoiding hand-to-mouth contact to the extent possible, washing hands and face or using hygienic wipes to remove potential contaminants from hands and face prior to breaks or lunch or other hand to mouth activities will restrict the most predominant route of exposure. ***Liquids/gases*** – Primary contaminants in this case exist in liquid media and present a vapor or gas hazard threat, real time monitoring instruments and PPE will be employed to support protective measures. As part of the evaluation method of these subsurface media, all samples will be scanned with a PID to determined potential source concentration. 2) **Transfer of Contamination into Clean Areas or onto Persons** - Restrict the cross use of equipment and supplies between locations and activities without first going through a suitable decontamination. Work practices including establishing a rigid decontamination procedure will be employed for all equipment between locations and between clean and potentially dirty work. This provision along with dedicated sampling equipment will insure materials are not carried and deposited in unaffected areas. ***Physical hazards:*** 3) **Heavy Equipment Hazards** - All equipment will be: - Inspected in accordance with Federal safety and transportation guidelines, OSHA (1926.600.601.602), and manufacturer's design, as applicable. All inspections will be documented using the Equipment Inspection Checklist (for Drill Rigs) found in (See Attachment III**)** of this HASP. - Operated and supported by knowledgeable operators and ground crew. - Used within safe work zones, with routes of approach clearly demarcated. All personnel not directly supporting this operation will remain at least 35 feet from the point of operation or the height of the mast plus 5-feet. See Section 10.1.1 of this HASP. This will be the area identified as the exclusion zone. - All self-propelled equipment shall be equipped with movement warning systems. - All personnel will be instructed in the location and operations of the emergency shut-off device(s). This device will be tested initially (and then periodically) to ensure its operational status. - One person (usually the driller) will be designated as the Emergency Shut Off Device Operator. - Prior to engaging the augers, the driller will announce, loud enough for all to hear that he is engaging the augers. He will visually confirm that all personnel are removed from the rotating equipment then engage the augers. - Areas will be inspected prior to the movement of the direct push rig and support vehicles to eliminate any physical hazards. This will be the responsibility of the FOL and/or SHSO. - See additional safe work procedures for drilling in Section 5.9 of this HASP as well as in Section 4.0 of the HSGM. 4) **Noise in Excess of 85 dBA** - Hearing protection will be used during all subsurface activities using the HSA Drill Rig and direct push rig or when noise levels are >85 dBA. (during operation). Previous accumulated data indicates an average 8 hour exposure working behind a direct push rig during hydraulic and hammer advancement of the tooling is approximately 87-92 dBA. . Controlling this hazard shall be accomplished employing two separate approaches as follows: - Boundaries will be established to limit the affect of the noise hazard. The height of the mast + 5 feet or a minimum of 35 feet will remove personnel far enough from the noise source as not to present a noise exposure concern. - Hearing protection *Excessive noise levels (>80dBA) are being approach when you have to raise your voice to talk to someone within 2 feet of your location.* 5) **Energized Systems** - All drilling activities will proceed in accordance with the Utility Locating and Excavation Clearance SOP in Attachment II of this HASP. All utility clearances will be obtained in writing, and locations identified and marked, prior to activities. If it is not obtainable/unknown or you location infringes within 3-feet of an underground utility advancement must proceed by hand until past the utility. The hand dug hole must at least represent the same diameter of the mechanized tooling that will be used. Utility clearance is being provided by NCBC Gulfport. 6) **Lifting Hazards** - Use machinery or multiple personnel for heavy lifts. Use proper lifting techniques as described in Table 5-1 for mobilization/demobilization. Drill stems, auger flights, and well construction supplies are some of the common material that are handled and because of their weight will present a lifting strain hazard associated with this activity. 7) **Slips, Trips, and Falls** - Preview work locations for unstable/uneven terrain. - Cover, guard and barricade all open pits, ditches, and floor opening as necessary. - Ruts, roots, tools, and other tripping hazards should be eliminated approaching points of operation to minimize trips and falls when approaching operating equipment. - Maintain a clutter free work area. - As part of site control efforts construct fences or other means of demarcation (i.e. signs and postings) to control and isolate traffic in the work area. Means of demarcation shall also be constructed isolating resource and/or staging areas. 8) **Cuts and Lacerations** - To prevent cuts and lacerations, the following provisions are required: - Obtain and use the knife and acetate tube retention tub recommended by Geoprobe (Geoprobe Sampling Kit) to prevent potential cuts and lacerations when accessing samples within MacroCore acetate liners. These items have been engineered to allow sample acquisition without putting the sampler at risk. - Always cut away from yourself and others, then, if a knife slips, you will not impale yourself or others. - Do not place items to be cut in your hand or on your knee. - Change out blades as necessary to maintain a sharp cutting edge. Many accidents result from struggling with dull cutting attachments. - Wear cut-resistant gloves (leather or heavy cotton) 9) **Vehicular and Foot Traffic Hazards** - Use traffic-warning signs, flag persons, and high visibility vests as determined by the SHSO when working along traffic thoroughfares. In addition, use physical barricades, when working within normal traffic flow patterns/traffic lanes. ***Natural hazards:*** 10) **Inclement Weather** – To minimize hazards of this nature, the following provisions shall be employed: - Wear appropriate clothing for weather conditions. - Provide acceptable shelter and replacement liquids for field crews as relief from excessive ambient temperatures. - Under conditions of elevated levels of PPE, periods of acclimatization, excessive ambient temperature extremes, or if you believe someone is suffering from a heat/cold related disorder, it may be necessary to conduct heat/cold stress monitoring. - Electrical storms/high winds - Suspend or terminate operations until directed otherwise by SHSO. Follow the provisions as specified in Section 4.0 of the Tetra Tech NUS, Inc. Health and Safety Guidance Manual regarding the identification and evaluation of heat/cold stress related conditions. 11) **Insect bites/Snakes/Alligators** See Multi-media sampling for protective measures. These hazards are not anticipated to be as predominant during this activity or in this area.	1) Monitoring shall be conducted to qualify and quantify estimated source concentrations of on-site contaminants in support of the prescribed worker protection levels. Monitoring shall be conducted using Photoionization Detector (PID) with 10.6eV lamp strength. Colorimetric tubes (Vinyl Chloride 1/a) Site 4 Action Level – 5 ppm sustained in the workers breathing zone sustained for greater than 10 minutes duration. Confirm that the airborne contaminant is not VC using Drager colorimetric tube. No more than 4 occurrences are permitted in a single day. Action levels of this level will protect personnel from achieving the most conservative TLV/TWA. If it is vinyl chloride temporarily suspend activities until airborne concentrations recede to acceptable levels. Sustained airborne concentrations above the identified action levels will result in ceasing the operation until airborne concentrations recede below acceptable levels. Failure of these concentrations to diminish will require an upgrade in the level of protection and therefore a modification of this HASP. Contact the PHSO. Monitoring shall be conducted at the prescribed depths as indicated on the boring logs at the source (borehole) and drillers breathing zone. Monitoring shall also be conducted at the sampler's location to in the same prescribed frequency when handling samples. Noise monitoring may be conducted at the discretion of the PHSO and/or the SHSO. Action Level - >85 dBA Participation in the Project Hearing Conservation Program. Hearing protection is required for this operation.	All soil boring operations and monitoring well installation will be initiated in Level D protection, including the following articles: Sampler/Oversight Personnel - Standard field dress (long pants, Sleeved shirts) - Steel toe safety shoes or work boots - Hard hat(when within 35-feet of the drill rig) - Safety Glasses(when within 35-feet of the drill rig or when sampling) - Nitrile surgeon style inner gloves for sampling - Hearing protection(when within 35-feet of an operating drill rig) - *Impermeable boot covers* - *Reflective vest for traffic areas* **Driller and Driller Helper** - Standard field attire including sleeved shirt and long pants - Safety shoes (Steel toe/shank) - Safety glasses - Nitrile inner and outer gloves or supported neoprene - Hearing protection - Hard hat - Impermeable aprons are recommended for handling contaminated auger flights and drill stems against the body. The apron will prevent soiling and saturation of work clothes - *Impermeable boot covers* **Upgrades to Level C and B protection** are not anticipated. **Note:** Use of respiratory protection will require the implementation of the Tetra Tech NUS, Inc. Respiratory Protection Program provided in the Health and safety Guidance Manual. As site conditions may change, the following equipment will be maintained during all on-site activities - Fire Extinguishers - First-aid Kit **Note:** The Safe Work Permit(s) for this task (See Attachment IV of this HASP) will be issued at the beginning of each day to address the tasks planned for that day. As part of this task, additional PPE may be assigned to reflect site-specific conditions or special considerations or conditions associated with any identified task.	**Personnel Decontamination** will consist of a soap/water wash and rinse for reusable and non-reusable outer protective equipment (boots, gloves, impermeable apron, as applicable Gross contamination of outer boots and outer gloves will be removed at a satellite location near the operation. Final wash and rinse will take place at the centralized decontamination pad. The sequential procedure is as follows: Stage 1: Equipment drop Decontamination personnel will clean hand tools as necessary. Stage 2: Soap/water wash and rinse of outer boots as applicable and gloves Stage 3: Soap/water wash and rinse of the impermeable apron, as applicable. Stage 4: Disposable PPE will be removed and bagged. Stage 5: Wash face and hands Note: For remote locations away from the centralized decontamination unit - Bag and/or wrap all disposable and reusable equipment, respectively for transport back to the decontamination unit. - Hygienic wipes may be used for cleaning hands and face **Equipment Decontamination** - All heavy and sampling equipment decontamination will take place at a centralized decontamination pad utilizing a steam cleaner or pressure washer as prescribed in Table 5-1 for that task. Heavy equipment will have the wheels and tires cleaned along with any loose debris removed, prior to transporting to the central decontamination area. All site vehicles will have restricted access to exclusion zones. Vehicles will have their wheels/tires cleaned or sprayed off as applicable as not to track mud onto the roadways servicing this installation. Roadways shall be cleared of any debris resulting from the onsite activity. The FOL or the SHSO will be responsible for evaluating equipment arriving on-site, leaving the site, and between locations. No equipment will be authorized access, exit, or movement to another location without this evaluation.

TABLE 5-1
TASKS/HAZARDS/CONTROL MEASURES NCBC GULFPORT, GULFPORT, MISSISSIPPI

Tasks/Operation/**Locations**	**Anticipated Hazards**	**Recommended Control Measures**	**Hazard Monitoring - Type And Action Levels**	**Personal Protective Equipment** *(Items In Italics Are Deemed Optional As Conditions Or The FOL Or the SSO Dictate.)*	**Decontamination Procedures**
Surveying – Geophysical and Geographical The locations identified to be surveyed are largely within improved and well maintained areas. Therefore, the necessity to cut clear lines from vertical and horizontal control monuments is not anticipated. In addition, it will be necessary to establish grids to conduct the geophysical surveying. Again, as this is a well maintained area clearing for grid lines is not anticipated.	***Chemical hazards:*** Significant exposure to site contaminants is not anticipated during this task. ***Physical hazards:*** 1) Slips, trips, and falls 2) Struck by 3) Traffic hazards ***Natural hazards:*** 4) Inclement weather 5) Insect/animal bites or stings, poisonous plants, etc.	***Physical hazards:*** 1) Preview work locations and site lines for uneven and unstable terrain. Clear necessary vegetation, establish temporary means for traversing hazardous terrain (i.e., rope ladders, etc.) as necessary. A review of accident/injury statistics associated with land surveying identify slips, trips, and falls as the number one injury, followed by cuts and lacerations, and animal/insect bites. 2) If hand tools (brush hooks, machetes, etc.) are necessary to clear and carry lines and bench marks to the area of operation the following precautions are recommended: - Insure handles are of good construction (no cracks, splinters, loose heads/cutting apparatus. - Insure all cutting tools are maintained. Blades shall be sharp without knicks and gouges in the blade. - All hand tools (brush hooks, machetes, etc.) with cutting blades shall be provided with a sheath to protect individuals, when not in use. - All personnel will maintain a 10-foot perimeter around persons clearing brush. **Note:** It is not anticipated that trees >2-inch girth will be required to be dropped as part of this operation or that significant amount of clearing will be required. Therefore the use of chainsaws and chippers is not anticipated. Note: Where possible it is recommended that heavy equipment (tractors and brush hogs or similar equipment) be used to clear grid lines and lines of site. 3) Vehicular traffic hazards - Wear high visibility vests when working in traffic patterns. - Provide signage in areas where traffic patterns will be altered (Survey crew working; lane restriction, etc.). ***Natural hazards:*** 4) Electrical storms or high winds - Suspend or terminate operations until directed otherwise by SHSO. Harmful effects of the Sun - Care should be exercised when working outdoors due to harmful effects of the sun. To reduce the potential for sunburn and melanoma the following measures should be employed - Wear a hat that shades the face, neck, and ears. - Apply sunscreen with a SPF of 15 or higher liberally on any exposed skin at least 15 minutes before going outside, then at least every two hours, more if you are sweating a lot. - To the extent possible, plan/provide suitable equipment to offer shade to avoid the midday sun since the sun's ultraviolet rays are most intense between 10 A.M. and 4 P.M. and can damage your skin even on hazy days. - Wear wrap-around sunglasses to protect the eyes and delicate skin around them. 5) **Insect/Animal Bites and Stings** - This is not considered a predominant hazard as these activities are to be conducted in maintained areas separating the driving range and the first tee box. Some of the sample locations to be surveyed will bring personnel along waters edge. To combat the potential impact of natural hazards, the following actions are recommended Snakes - Items laying on the ground provide cover and nesting locations. If you must pick something up to move it always pull it towards your body to provide a shield. - Well pads often provide preferred sunning areas for snakes - Leave snakes and animals alone, do not harass or try to capture. Contact the SHSO for direction in the removal of animals and snakes within the confines of the work site. - Snake chaps or high leather boots should be worn in unimproved or unmaintained areas on an initial sweep of the area. - Keep hands and feet out of areas you cannot see. Alligators - Do not harass or otherwise bother an alligator - Remember they are more aggressive during mating and nesting period - Buddy System – Always use two people when performing duties in areas where alligators exist. One to serve as a watch while the other completes the surveying. - Boats – Where possible use a boat to isolate yourself from their environment. It is never recommended that waders be employed in alligator infested waters. - Nesting areas – These areas are usually marked by mounded areas of grasses and mud. A telltale characteristic of these nests is the noticeable slide marks leading from the mound into the water. Avoid these areas. Insects and spiders - Wear light color clothes. This will allow easier detection of ticks and insects crawling on your body. It will also assist in heat stress control. - Tape pant legs to work boots to block direct access. This is especially critical when clearing or entering heavy brush and wooded areas. - Use repellents – Follow manufacturer's recommendations for use. Permanone should be applied liberally to the clothing, but not the skin as it may cause irritation. Concentrate on areas where ticks and other insects may access your body such as pant cuffs, shirt to pants, and collars. - Upon exiting the high brush and wooded areas perform a close body inspection to remove any ticks or other insects that have attached to your clothing or skin. - Do not stick your hand anywhere where you can't see. - When opening existing well heads be cautious of bees and spiders as these are preferred nesting locations. - As this activity may take personnel into areas of heavier vegetation, surveyors should be cognizant of poison ivy, poison oak, and poison sumac in the area. See Section 6.3 of this HASP for descriptions of these plants. Protective measures to be used to minimize hazards of this nature a) Avoid direct contact through the use of Tyvek coveralls, clothing, or barrier creams b) Wash after contact with cool water and mild soap. c) Wash equipment contaminated with the oils of these plants to avoid cross contamination. See Section 4.0 of the TtNUS Health and Safety Guidance Manual for additional information concerning natural hazards.	Air monitoring is not required given the unlikelihood that airborne contaminants will be present. The potential for exposure to site contaminants during this activity is considered minimal.	Surveying activities shall be performed in Level D protection Level D Protection consists of the following: - Standard field dress including sleeved shirt and long pants - Shoes rugged lug sole for traction - Work gloves shall be worn when clearing brush. - *Safety glasses, hard hats (if working near machinery, overhead hazards, or clearing brush)* - *Snake chaps for heavily wooded area where encounters are likely.* - *Tyvek coveralls may be worn to provide additional protection against poisonous plants and insects, particularly ticks.* - *Reflective or blaze orange vests should be worn when working along traffic thoroughfares.* **Note:** The Safe Work Permit(s) for this task (See Attachment IV) will be issued at the beginning of each day to address the tasks planned for that day. As part of this task, additional PPE may be assigned to reflect site-specific conditions or special considerations or conditions associated with any identified task.	**Personnel Decontamination** - A structured decontamination is not required as the likelihood of encountering contaminated media is considered remote. However, survey parties should inspect themselves and one another for the presence of ticks when exiting wooded areas, grassy fields, etc. This action will be employed to stop the transfer of these insects into vehicles, homes, and offices. In addition, early detection shall provide for early removal.

TABLE 5-1
TASKS/HAZARDS/CONTROL MEASURES NCBC GULFPORT, GULFPORT, MISSISSIPPI

Task/Operation/Location	Anticipated Hazards	Recommended Control Measures	Hazard Monitoring - Type and Action Levels	Personal Protective Equipment *(Items in italics are deemed optional as conditions or the FOL or SHSO dictate.)*	Decontamination Procedures
Multi-media sampling, including - Monitoring Well Development using whale pumps and surge blocks - Hydraulic Conductivity testing using slugs - Groundwater Sampling – Redi-Flo and peristaltic pumps - Natural Attenuation sampling - Subsurface soils – MacroCore samplers, disposable trowels. This activity will primarily be addressed under soil boring and monitoring well installation. - Sediment and surface water sampling Hazards are anticipated to be similar in all of these activities.	***Chemical hazards:*** 1) Previous analytical data identified the following compounds have been identified as contaminants of concern Site 4- Groundwater Vinyl chloride 37 ppb in well GPT-4-5 Further information on these contaminants are presented in Section 6.1 and Table 6-1. Chemical reagents and sample preservatives provided by the analytical laboratory. 2) Transfer of contamination into clean areas. ***Physical hazards:*** 3) Slip, trip, and fall hazards 4) Strain/muscle pulls from manual lifting 5) Cuts and Lacerations 6) Ambient temperature extremes (heat/cold stress) 7) Site Characterization 8) Water Hazards - Drowning ***Natural hazards:*** 9) Animal and insect bites and encounters 10) Inclement weather	***Chemical hazards:*** 1) Safe work practices will be employed as the first line of defense. As a general rule, avoiding contact with contaminated media (water, soils, etc.) will be employed as a universal control measure. In addition, good work hygiene practices including avoiding hand-to-mouth contact to the extent possible, washing hands and face or using hygienic wipes to remove potential contaminants from hands and face prior to breaks or lunch or other hand to mouth activities will restrict the most predominant route of exposure. ***Liquids/gases*** – Primary contaminants in this case exist in liquid media and present a vapor or gas hazard threat, real time monitoring instruments and PPE will be employed to support protective measures. As part of the evaluation method of these subsurface media, all samples will be scanned with a PID to determined potential source concentration. When sampling groundwater wells exposure potential is the greatest when opening a well that has been sealed and that gases have built up inside. The following practice should be employed - At arms length, open the well and step away. Let the well off gas for a few minutes, while you prepare your equipment . Airborne concentrations will recede and you can continue with your task. Monitoring Natural Attenuation – Review MSDSs for chemical reagents and preservatives that area used. 2) **Transfer of Contamination into Clean Areas** - Decontaminate all equipment and supplies between sampling locations and prior to leaving the site. See decontamination of heavy and sampling equipment for direction in this task. In addition, the bulk of sampling equipment (i.e., tubing, trowels are disposable therefore dedicated). In addition, Rinsate samples will be collected 1/20 samples to evaluate the decontamination procedure and to evaluate dedicated equipment. 3) **Slip, Trip, and Fall Hazards** – These hazards shall be minimized by adherence to the practices listed below. This includes - Maintain proper housekeeping in all work areas. - Preview and inspect work areas to identify and eliminate slip, trip, or fall hazards. - Cover, guard, barricade, and or place warning postings over/at holes or openings that personnel may fall or step into. - For traversing steep, slippery, or sloped terrain establish rope ladders to control ascent and descent to sampling areas or use alternative pathways. - Use lifeline to sample along waters edge - Use multiple persons and pack small loads to remote locations. 4) **Strain/Muscle Pulls from Manual Lifting** - Use machinery or multiple personnel for heavy lifts. Use proper lifting techniques (See Lifting Mobilization/Demobilization, Page 1 of 6, Table 5-1). 5) **Cuts and Lacerations** – Employ the following measures to reduce and/or eliminate the potential for cuts and lacerations - Select and secure the most favorable route to monitoring wells and sampling locations. - Previewing pathways - Where possible, remove or demarcate the physical hazards. - Inspect all cutting equipment to be used to clear access routes for defects. - When cutting items - always use a sharp knife and always cut away from your body. Do not place items to be cut in your opposite hand or on your knee. - Carry all glassware and items that present a potential for cuts, lacerations, or impalement such as machetes or brush hooks in protective packaging or sheathed to avoid breakage or exposure in the event of a slip, trip, and/or fall. 6) **Ambient Temperature Extremes (Heat/Cold Stress)** - Wear appropriate clothing for weather conditions. Provide acceptable shelter and liquids for field crews. Additional information regarding heat/cold stress is provided in Section 4.0 of the Health and Safety Guidance Manual. Care should be exercised when working outdoors due to harmful effects of the sun. To reduce the potential for sunburn and melanoma the following measures should be employed - Wear a hat that shades the face, neck, and ears. - Apply sunscreen with a SPF of 15 or higher liberally on any exposed skin at least 15 minutes before going outside, then at least every two hours, more if you are sweating a lot. - Plan/provide suitable equipment to offer shade to avoid the midday sun since the sun's ultraviolet rays are most intense between 10 A.M. and 4 P.M. and can damage your skin even on hazy days. - Wear wrap-around sunglasses to protect the eyes and delicate skin around them. 7) **Site Characterization** - Work areas will be surveyed prior to committing personnel or resources. The survey will be conducted by the FOL and/or the SHSO. The purpose is to identify physical and natural hazards that may impact the proposed work area. These hazards are to be identified, barricaded, or eliminated to the extent possible to minimize potential effect to field crew. 8) Water hazards – Drowning – Personnel will be required to work along waters edge in the collection of surface water/sediment sampling. Due to natural hazards persons are not to wade into the water to collect these samples. Those persons working along waters edge will perform the following - Have a buddy to watch for alligators as well as through a life line to pull out anyone who accidental falls into the water. - If sampling will occur from a boat persons will wear USCG approved Floatation Devices. 9) **Insect/Animal Bites and Stings** - This is not considered a predominant hazard as these activities are to be conducted in well maintained areas. However, the hazard may be more prominent during surface water and sediment sampling which will bring personnel along waters edge. To combat the potential impact of natural hazards, the following actions are recommended Snakes - Items laying on the ground provide cover and nesting locations. If you must pick something up to move it always pull it towards your body to provide a shield. - Well pads often provide preferred sunning areas for snakes - Leave snakes and animals alone, do not harass or try to capture. Contact the SHSO for direction in the removal of animals and snakes within the confines of the work site. - Snake chaps or high leather boots should be worn in unimproved or unmaintained areas on an initial sweep of the area, if you are unknowledgeable regarding nesting and habitat considerations for indigenous animals and reptiles. - Keep hands and feet out of areas you cannot see. Alligators - Do not harass or otherwise bother an alligator - Remember they are more aggressive during mating and nesting periods. - Buddy System – Always use two people when performing duties in areas where alligators exist. One to serve as a watch while the other completes the sampling. - Remote sampling devices – Use remote sampling devices such as extended poles, dredges etc. for sediment and surface waters to remove personnel from the water or waters edge. - Boats – Where possible use a boat to isolate yourself from their environment. It is never recommended that waders be employed in alligator infested waters. - Nesting areas – These areas are usually marked by mounded areas of grasses and mud. A telltale characteristic of these nests is the noticeable slide marks leading from the mound into the water. If at all possible avoid these areas.	1) Monitoring shall be conducted to qualify and quantify estimated source concentrations of on-site contaminants in support of the prescribed worker protection levels. Monitoring shall be conducted using Photoionization Detector (PID) with 10.6eV lamp strength. Colorimetric tubes (Vinyl Chloride 1/a) Site 4 Action Level – 5 ppm sustained in the workers breathing zone sustained for greater than 10 minutes duration. Confirm that the airborne contaminant is not VC using Drager colorimetric tube. No more than 4 occurrences are permitted in a single day. Action levels of this level will protect personnel from achieving the most conservative TLV/TWA. If it is vinyl chloride temporarily suspend activities until airborne concentrations recede to acceptable levels. Sustained airborne concentrations above the identified action levels will result in ceasing the operation until airborne concentrations recede below acceptable levels. Failure of these concentrations to diminish will require an upgrade in the level of protection and therefore a modification of this HASP. Contact the PHSO. Monitoring shall be conducted at the prescribed depths as indicated on the boring logs at the source (borehole) and drillers breathing zone. Monitoring shall also be conducted at the sampler's location to in the same prescribed frequency when handling samples. Noise monitoring maybe conducted at the discretion of the PHSO and/or the SHSO. Action Level - >85 dBA Participation in the Project Hearing Conservation Program. Hearing protection is required for this operation.	Level D protection will be utilized for the following sampling activities - Monitoring Well Development - Hydraulic Conductivity testing - Groundwater Sampling – Redi-Flo and 1-inch Whale pumps - Natural Attenuation sampling - Subsurface soils – MacroCore Samplers, disposable trowels. Sampler/Oversight Personnel - Standard field dress (long pants, Sleeved shirts) - Steel toe safety shoes or work boots - Safety Glasses - Nitrile surgeon style inner gloves for sampling - *Hearing protection* (when within 25-feet of an operating direct push rig or 35-feet of a HSA Rig) - *Impermeable boot covers* - *Reflective vest for traffic areas* Protective Measures as specified for drilling and soil boring will be employed for all subsurface soil sampling at the drill rig. **Upgrades to Level C and B protection** are not anticipated. **Note:** Use of respiratory protection will require the implementation of the Tetra Tech NUS, Inc. Respiratory Protection Program provided in the Health and safety Guidance Manual. This action will require this HASP to be modified for this elevated level of protection. **Note:** The Safe Work Permit(s) for this task (See Attachment IV) will be issued at the beginning of each day to address the tasks planned for that day. As part of this task, additional PPE may be assigned to reflect site-specific conditions or special considerations or conditions associated with any identified task.	**Personnel Decontamination** Upon completion of the sampling - Dedicated trowels, tubing, PPE will be rinsed and bagged for disposal. - Handi-Wipes or similar product will be used to clean hands, prior to moving to the next location. **Equipment Decontamination** Decontamination of equipment (sampling and hand tools) will proceed as indicated in Table 5-1 of this HASP and/or the Workplan.

TABLE 5-1
TASKS/HAZARDS/CONTROL MEASURES NCBC GULFPORT, GULFPORT, MISSISSIPPI

Task/Operation/Location	Anticipated Hazards	Recommended Control Measures	Hazard Monitoring - Type and Action Levels	Personal Protective Equipment *(Items in italics are deemed optional as conditions or the FOL or SHSO dictate.)*	Decontamination Procedures
		Insects and spiders - Wear light color clothes. This will allow easier detection of ticks and insects crawling on your body. It will also assist in heat stress control. - Tape pant legs to work boots to block direct access. This is especially critical when clearing or entering heavy brush and wooded areas. - Do not stick your hand anywhere where you can't see. - When opening existing well heads be cautious of bees and spiders as these are preferred nesting locations. - Use repellents – Follow manufacturer's recommendations for use. Permanone should be applied liberally to the clothing, but not the skin as it may cause irritation. Concentrate on areas where ticks and other insects may access your body such as pant cuffs, shirt to pants, and collars. - If you leave your workboots at the trailer or office over your break make sure you shake them out bef ore sticking your feet in them. See Section 4.0 of the HSGM for more information concerning these natural hazards. 10) Suspend or terminate operations during electrical storms. Return to work when directed by the FOL and/or the SHSO.			

TABLE 5-1
TASKS/HAZARDS/CONTROL MEASURES NCBC GULFPORT, GULFPORT, MISSISSIPPI

Tasks/Operation/Locations	Anticipated Hazards	Recommended Control Measures	Hazard Monitoring - Type and Action Levels	Personal Protective Equipment *(Items in italics are deemed optional as conditions or the FOL or SHSO dictate.)*	Decontamination Procedures
Decontamination of Heavy Equipment Decontamination of sampling equipment. It is anticipated that this activity will take place at a temporary centralized location. Gross contamination will be removed to the extent possible at the site. Contaminated tooling then will be wrapped in polyethylene sheeting for transport to the centralized location for a full decontamination and evaluation.	***Chemical hazards:*** 1) Previous analytical data identified the following compounds as contaminants of concern Vinyl chloride (VC) in the groundwater It is however, not anticipated to be a exposure hazard during this activity 2) Decontamination fluids - Liquinox (detergent); isopropanol (decontamination solvent) ***Physical hazards:*** 3) Lifting (strain/muscle pulls) 4) Noise in excess of 85 dBA 5) Flying projectiles 6) Falling hazards 7) Slips, trips, and falls ***Natural hazards:*** 8) Inclement weather	1) and 2) Employ protective equipment to minimize contact with site contaminants and hazardous decontamination fluids. Control potential non-occupational exposures through good work hygiene practices (i.e., avoid hand to mouth contact; wash hands and face before breaks and lunch; minimize contact with contaminated media). Obtain and familiarize yourself with manufacturer's MSDS for any decontamination fluids used on-site. Solvents may only be used in well-ventilated areas, such as outdoors. Use appropriate PPE as identified on MSDS or within this HASP. All chemicals used must be listed on the Chemical Inventory for the site, and site activities must be consistent with the Hazard Communication Program provided in Section 5.0 of the TtNUS Health and Safety Guidance Manual. 3) Use multiple persons where necessary for lifting and handling heavy equipment for decontamination purposes. - Employ proper lifting techniques as described in Table 5-1, Mobilization/Demobilization. 4) Wear hearing protection when operating the pressure washer and/or steam cleaner. Sound pressure levels measured during the operation of similar pieces of equipment indicate a range of 87 to 93 dBA. 5) Use eye and face protective equipment when operating the pressure washer and/or steam cleaner, due to flying projectiles. All other personnel must be restricted from the area. In addition to minimize hazards (flying projectiles, water lacerations and burns) associated with this operation, the following controls will be implemented - A Fan Tip 25° or greater will be used on pressurized systems over 3,000 psi. This will reduce the possibility of water lacerations or punctures. - Do not point the wand at persons or place against any part of your body. - Thermostat control will be in place and operational to control the temperature levels of the water where applicable. - Visual evaluations of hoses and fittings for structural defects - Construct deflection screens as necessary to control overspray and to guard against dispersion of contaminants driven off by the spray. 6) Insure wash and drying racks are of suitable construction to prevent heavier items such as auger flights and drill rods from falling and striking someone during the decontamination process. 7) The decontamination pad should be constructed to contain wash waters generated during decontamination procedures. Temporary decontamination pads are usually 10-30 mil polyethylene or polyvinyl chloride tarp construction. Although these items when used as a liner offer containment, they also present a slipping hazard. When these temporary liners are employed, it is recommended that a light coating of sand be spread over the walking surface to provide traction. - In addition, adequate slope should be provided to the pad to permit drainage away from the object being cleaned. The collection point for wash waters should be of adequate distance that the decontamination workers do not have to walk through the wash waters while completing their tasks. - Hoses should be gathered when not in use to eliminate potential tripping hazards. 8) Suspend or terminate operations until directed otherwise by SHSO.	Use visual observation and real-time monitoring instrumentation to ensure all equipment has been properly cleaned of contamination and dried. Monitoring instrumentation will be employed to determine If contaminants and all of the decontamination solvent (isopropanol) (where use is applicable) has been removed through the rinse process. Any positive indication/results greater than background require the article that has been decontaminated to be re-rinsed and scanned again. If necessary this process should be repeated until no measurable indication of contaminants and/or the decontamination solvent exists.	<u>For Heavy Equipment</u> This applies to pressure washing and/or steam cleaning operations and soap/water wash and rinse procedures. Level D Minimum requirements: - Hard hat with splash shield - Standard field attire (Long sleeve shirt; long pants) - Safety shoes (Steel toe/shank) - Chemical resistant boot covers - Nitrile outer gloves over nitrile inner gloves - Safety glasses underneath a splash shield - Hearing protection (plugs or muffs) - *Hooded PVC Rainsuits or PE or PVC coated Tyvek.* Impermeable aprons may be used instead of coveralls if they offer adequate protection against overspray and back splash. **For sampling equipment** (trowels, split spoons,, etc.), the following PPE is required **Note**: Consult MSDS for PPE guidance. Otherwise, observe the following. Level D Minimum requirements - - Standard field attire (Long sleeve shirt; long pants) - Safety shoes (Steel toe/shank) - Nitrile outer gloves over nitrile inner gloves - Safety glasses - *Impermeable apron* **Note:** The Safe Work Permit(s) for this task (See Attachment IV) will be issued at the beginning of each day to address the tasks planned for that day. As part of this task, additional PPE may be assigned to reflect site-specific conditions or special considerations or conditions associated with any identified task.	**Personnel Decontamination** will consist of a soap/water wash and rinse for reusable and non-reusable outer protective equipment (boots, gloves, PVC splash suits, as applicable). The sequential procedure is as follows: Stage 1: Equipment drop, remove outer protective wrapping; personnel will wash hand tools and pass hand equipment through as necessary. Stage 2: Soap/water wash and rinse of outer boots and gloves Stage 3: Soap/water wash and rinse of the outer splash suit or apron as applicable Stage 4: Disposable PPE will be removed and bagged. Stage 5: Wash face and hands **Equipment Decontamination** - All heavy equipment decontamination will take place at a centralized decontamination pad utilizing a steam cleaner or pressure washer. Heavy equipment will have the wheels and tires cleaned along with any loose debris removed, prior to transporting to the central decontamination area. **Sampling Equipment Decontamination** Sampling equipment will be decontaminated as per the requirements indicated within the Work Plan. All equipment used in the exclusion zone will require a complete decontamination between locations and prior to removal from the site. The FOL or the SHSO will be responsible for evaluating equipment arriving on-site, leaving the site, and between locations. No equipment will be authorized access, exit, or movement to another location without this evaluation.

TABLE 5-1
TASKS/HAZARDS/CONTROL MEASURES NCBC GULFPORT, GULFPORT, MISSISSIPPI

Tasks/Operation/Locations	Anticipated Hazards	Recommended Control Measures	Hazard Monitoring Type And Action Levels	Personal Protective Equipment (Items In Italics Are Deemed Optional As Conditions Or The FOL Or the SSO Dictate.)	Decontamination Procedures
IDW Management and Handling This activity includes the following tasks: - Containerization - Labelling - Staging - Monitoring of IDW generated in support of site activities.	***Chemical hazards:*** The only anticipated chemical hazard associated with IDW management is the potential for a spill. In situations such as that the spill containment program identified in Section 9.0 of this HASP will be employed. ***Physical hazards:*** 1) Strains and sprains 2) Back injuries 3) Compressions 4) Loading bulk transport containers	***Chemical hazards:*** It is not anticipated that chemical hazards will be significant during this operation, as the IDW will be in sealed containers. It is anticipated that the IDW will represent a limited chemical hazard, if the container is breached. Control measures in this case will represent PPE and good work hygiene practices to control potential exposures during the implementation of the Spill Containment Program (See Section 9.0 of this HASP). ***Physical hazards:*** 1 & 2) **Strains and sprains (lifting hazards)/Back Injuries** – The predominant hazard associated with this activity is the movement of full or partially full 55-gallong drums of soils and/or water. To minimize hazards of this nature the following provisions shall be incorporated as applicable: - Use machinery (preferred method) or multiple personnel for heavy lifts - Use proper lifting techniques a. Lift with your legs, not your back, bend your knees move as close to the load as possible, and ensure good hand holds are available. b. Minimize the horizontal distance to the center of the lift to your center of gravity. c. Minimize turning and twisting when lifting as the lower back is especially vulnerable at this time. d. Break lifts into steps if the vertical distance (from the start point to the placement of the lift) is excessive. e. Plan your lifts – Place heavy items on shelves between the waist and chest; lighter items on higher shelves. f. Periods of high frequency lifts or extended duration lifts should provide sufficient breaks to guard against fatigue and injury. In determining whether you can lift or move an item several factors must be considered, these are as follows: - Area available to maneuver the lift. - Area of the lift – Work place clutter, slippery surfaces, rough terrain - Overall physical condition **3) Compressions** – Another hazard frequently associated with this task is the compression of hands and fingers when placing the containers on pallets. This typically occurs when rolling and lowering the container in its place. To combat this hazard, the following provision shall be employed: Material handling devices shall be used for moving drums within the satellite storage area. This includes drum dollies with pneumatic tires, drum grapplers, etc. to handle drums of IDW. These pieces of equipment are engineered to allow placement of these containers while keeping hands from pinch/compression points. **Reminder:** The drums you are attempting to move, lift and/or relocate may weigh on the average of - 55-Gallon container of purge or decontamination waters = 475 lbs. (including the container) - 55-Gallon container of soils (moist) = 750 lbs. (including the container) Satellite Storage Area – Emphasis has been placed on the physical surroundings and how they can influence the potential hazards associated with material handling aspects of this task. To further reduce material handling hazards, support spill containment and control, and sampling when necessary, the IDW storage area should be structured as follows: - Maximum 4-drums to a pallet with retaining ring bolt and label on the outside for easy access/reference. - Maintain a minimum of 4-feet between each row of pallets. This is the minimum distance necessary to wheel drums on a drum dolley - If the site is not secured, the satellite storage area shall be fenced and signs placed indicating the following: a. Primary Point of Contact (Preferably someone at the Base, and make sure they know they been identified as the Primary Point of Contact). b. Phone Number c. Emergency Contact (If different from the Primary) - Provide a Drum/Container Inventory to the Primary Point of Contact and to Emergency Services, if they deem it necessary. The inventory should contain: a. Each drum shall be assigned a unique identification number. This number shall be placed on the label and drum shell using a paint marker (Note: Do not paint the number on the lid as these have a tendency to get exchanged from time to time.) b. Types of waste materials (Subsurface soils, drill cuttings; purge/development waters, etc.) c. Volumes (Full or level associated with the container after completion of the project location) d. Where it was derived from (IDW should be separated by SWMU and media) e. Dates (For all filled containers and at the completion of work for that area or SWMU) f. Contact – For more information Note: All drums should be labeled with the same information.	None Required, unless spill containment provisions are invoked. Then monitoring will proceed as described in the activity associated with the task when the materials were generated such as Soil boring or well installation.	Level D - (Minimum Requirements) - Standard field attire (Sleeved shirt; long pants) - Safety shoes (Steel toe/shank) - Leather or canvas work gloves - *Safety glasses (When utilizing cables or slings to move the containers)* - *Hardhat (when overhead hazards exists, or identified as a operation requirement)* PPE changes may be made with the implementation of the Spill Containment Program. This represents the only anticipated modification to this level of protection.	Not required, unless the implementation of the Spill Containment Program is required due to a spill and/or release. At that point the decontamination procedures for those activities such as soil borings and/or well installation. The reference reflects the tasks conducted when the materials were generated.

6.0 HAZARD ASSESSMENT

This section provides information regarding the chemical, physical, and natural hazards associated with the sites to be investigated and the activities that are to be conducted as part of the scope of work. Table 6-1 provides information on potential chemical contaminants, including exposure limits, symptoms of exposure, physical properties, and air monitoring and sampling data.

6.1 CHEMICAL HAZARDS

The potential health hazards associated with NCBC Gulfport include inhalation, ingestion, and dermal contact of various contaminants that may be present in shallow and deep soils, sediments, surface water, and groundwater. As the focus of this field investigation is to sample various media, concentrations of the chemical hazards present are not fully determined. Based on the site history and the most recent sampling efforts, the following have been identified as the primary contaminants:

Chlorinated Solvents	**Concentration**	**Media**	**Date of Investigation**
Low Levels Dioxins		Groundwater	1987
Vinyl Chloride	37 ppb	Groundwater	1995
1,2-Dichloroethene (1,2-DCE)	180 ppb	Groundwater	1995
Trichloroethene (TCE)	4.7 ppb	Groundwater	1995
Arsenic		soil	1997
Low Levels Dioxins		soil	1997
Vinyl Chloride	21 ppb	Groundwater	1998
1,2-Dichloroethene (1,2-DCE)	220 ppb	Groundwater	1998
Trichloroethene (TCE)	12 ppb	Groundwater	1998

Due to age, dilution, and impurities these materials may not represent the pure compounds. The following information represents general categories of contaminants that may be encountered. With the exception of vinyl chloride the information concerning the other compounds are purely for informational purposes. Vinyl chloride is the only component that represents a reasonable inhalation exposure concern. This exposure concern will be evaluated during site activities using a PID and established action levels.

Chlorinated Solvents – These solvents generally express symptoms including

- Irritating at all points of contact. Chronic or elevated concentrations directly contacting the skin may result in dermatitis.

- Inhalation of high concentrations (not anticipated in an outdoor environment) can result in CNS effects including dizziness, blurred vision, overexcitement, narcotic effects, and unconsciousness. Systemic effects through inhalation can also result in altered (erratic) heart beat and possible cardiac arrest.

Dioxins – Also referred to as Polychlorinated Dibenzodioxins.

- 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) is considered one of the most potent teratogen known to man.

- Chloroacne reported in cases of exposure may be related to impurities of dibenzofurans

- Dioxin is an organic solid of white crystalline needles. Dioxin is not produced or used commercially in the US. It is a contaminant formed in the production of some chlorinated organic compounds, including a few herbicides such as silvex. It may also be formed during combustion of a variety of chlorinated organic compounds.

- Short-term: EPA has found dioxin to potentially cause the following health effects when people are exposed to it at levels above the MCL for relatively short periods of time: liver damage, weight loss, wasting of glands important to the body's immune system.

- Long-term: Dioxin has the potential to cause the following effects from a lifetime exposure at levels above the MCL: a variety of reproductive effects, from reduced fertility to birth defects; cancer.

Previously reported dioxin concentrations were extremely low (parts per quadrillion – ppq). Available information indicate that dioxins do not present an occupational exposure threat based on these reported concentrations.

Waste Oils/Petroleum Distillates – All fractions tend to produce localized skin and eye irritation and in some rare cases photosensitization. Higher concentrations may produce pulmonary irritation. These substances can usually be detected through visual and olfactory sensitization. Inhalation of lighter chained hydrocarbons may result in systemic effects including narcotic effect, dizziness, and euphoria. Excessive concentrations of the lighter end distillates can result in pulmonary and cardiac arrest. It should be noted that this information is provided for informational purposes only.

Information concerning these substances was provided as it was determined that materials of this nature were probably used as the accelerant during the waste disposal process. Therefore, they maybe encountered. These substances could present a dermal exposure concern however data does not indicate an inhalation hazard.

It is anticipated that the greatest potential for exposure to site contaminants is during intrusive activities (soil borings, sampling, etc.). Exposure to these compounds is most likely to occur through inhalation or dermal contact of contaminated soil or water, or through ingestion via hand-to-mouth contact during soil disturbance activities. For this reason, PPE and basic hygiene practices (e.g., washing face and hands before leaving site) will be extremely important. Inhalation exposure will be monitored using PID and Draeger tubes for Vinyl chloride (1/a). Given the nature of planned activities and that work will be conducted outside in the open air, however, it us highly unlikely that any appreciable airborne concentrations will be present.

Other sources of potential chemical exposure are decontamination fluids (e.g., Liquinox, isopropanol), and analytical preservatives. For any substances brought onto the site, the SHSO is responsible for instituting a site-specific Hazard Communication Program (see Section 5.0 of the TtNUS Health and Safety Guidance Manual) and for collecting the appropriate Material Safety Data Sheets (MSDS) from the chemical manufacturers/suppliers. The SHSO is also responsible for completing the Safe Work Permit for the decontamination task using the appropriate MSDS and for reviewing the contents of the MSDSs and Safe Work Permit with anyone who will use these substances.

Table 6-1
CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
NAVAL CONSTRUCTION BATALLION CENTER – GULFPORT, MISSISSIPPI

Substance	CAS No.	Air Monitoring Information	Air Sampling Information	Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
Vinyl chloride	75-01-4	PID: I.P. 9.99 eV, High response with PID and 10.2 eV lamp. FID: 40% response with FID.	Air sample using charcoal or Anasorb CMS sorbent tube; carbon disulfide desorption; gas chromatography-flame ionization detection; Sampling and analytical protocol shall proceed in accordance with NIOSH Method #1007, or OSHA Method #75.	OSHA: 1.0 ppm PEL 5.0 ppm (Ceiling) ACGIH: 5 ppm NIOSH: Lowest Feasible Concentration	Inadequate - Odor threshold 10-20 ppm. Gas Mask with a vinyl chloride Type N canister may be employed for concentrations up to 25 ppm. Canisters employed must have a minimum service life of 4-hrs. Exceedances over 25 ppm, must use a positive pressure demand, open-circuit, self-contained breathing apparatus, pressure demand type, with full facepiece. Refer to 29 CFR 1910.1017(g) for specific requirements based on atmospheric concentrations of vinyl chloride. **Recommended gloves:** Silver shield >6.00 hrs; Nitrile 5.70 hrs; or Viton 4.4 hrs	**Boiling Pt:** 7°F; -13.9°C **Melting Pt:** -256°F; -160°C **Solubility:** 0.1% @ 77°F; 25°C **Flash Pt:** 18°F; -8°C **LEL/LFL:** 3.6% **UEL/UFL:** 33% **Vapor Density:** 2.21 **Vapor Pressure:** 3.3 atm **Specific Gravity:** N.A. **Incompatibilities:** Oxidizers, copper, aluminum, peroxides, iron, steel, **Appearance and Odor:** Colorless gas or liquid (below 7°F) with a pleasant odor at high concentrations.	A severe skin, eye, and mucous membrane irritant(Liquid: frostbite) Narcotic effect causing weakness, abdominal pains, GI bleeding, and pallor skin or cyanosis. Chronic exposure has been linked to the formation of malignant tumors originating from blood lymphatic vessels in the liver (associated enlargement of the liver), and kidneys (angiosarcoma and nephroblastoma). Listed as a carcinogen by NTP, IARC and ACGIH.

6.2 PHYSICAL HAZARDS

In addition to the chemical hazards discussed above, the following physical hazards may be present during the performance of the site activities.

- Slips, trips, and falls
- Cuts (or other injuries associated with hand tool use)
- Lifting (strain/muscle pulls)
- Ambient temperature extremes (cold and heat stress)
- Pinches and compressions
- Heavy equipment hazards (rotating equipment, hydraulic lines, etc.)
- Energized systems (contact with underground or overhead utilities)
- Vehicular and foot traffic
- Noise in excess of 85 dBA
- Flying projectiles

Each of these physical hazards is discussed in greater detail in Section 4.0 of the TtNUS health and Safety Guidance Manual. Additionally, information on the associated control measures for these hazards are discussed in Table 5-1 of this HASP. Some of these hazards and the associated control measures are discussed below due to the emphasis on incident and injury history.

6.2.1 <u>Slips, Trips, and Falls</u>

Conditions such as steep terrain and/or heavy vegetation may create an increased potential for slip, trip, and fall hazards.

- The safest approach to sample points will be identified and cleared to permit field crew access to sample locations.
- Establish anchor points and rope handrails for traversing/ascending/descending angles and slopes greater than 45% grade.
- Footwear with an adequate traction.
- Prepare work areas by removing tripping hazards (ruts, roots, debris). This is especially critical around rotating equipment, where a fall into the rotating apparatus could be life threatening.

6.2.2 Cuts or Other Injuries Associated with Hand Tool Use

The clearing of brush and vegetation will be performed using hand tools that may include machetes, and brush axes. However, the use of hand tools has only briefly discussed. The control measures presented below will help minimize the potential for physical and cutting hazards.

- Wear leather or heavy cotton work gloves when using tools to protect against blisters, cuts, or other hand injuries.
- Wear eye protection (safety glasses with side shields) to protect the eyes from twigs, sticks, or flying debris.
- Clear the immediate cutting area of personnel (radius of the tool swing area).
- Wear long pants and long-sleeved shirts to protect against abrasions.
- Wear hard hats if work will involve areas with overhead hazards (e.g., overhanging branches).
- Wear sturdy work boots.
- Inspect hand tools [i.e., shovel handles (cracks, splinters, etc.), brush hook handles and blade attachment points, etc.)
- Ensure that hand tools are sharp to facilitate cutting action. This will avoid persons forcing the tool to cut and increasing potential hazards.
- Use the proper tool for the intended purpose. The proper tool is the acetate tube retention tub recommended by Geoprobe. This will avoid potential injury possibly created through improper cutting procedures.

6.2.3 Energized Systems (Contact with Underground or Overhead Utilities)

Underground utilities such as pressurized lines, water, telephone, buried utility, and high voltage power lines may be present throughout the facility. Therefore, subsurface activities must be conducted following the requirements of the Tetra Tech NUS SOP for “Utility Locating and Excavation Clearance (HS-1.0)”. A copy of this SOP is provided as Attachment II. Clearance of underground and overhead utilities for each location will be coordinated with the NCBC Gulfport Public Works Department – Maintenance Division through Mr. Gordon Crane giving them a 10-Day advance notification.

Additionally, DPT/HSA operations will be conducted at a safe distance from overhead power lines as discussed in Attachment II (Minimum 20-feet). In certain cases, there may be a need to de-energize electrical cables using facility lockout/tagout procedures to insure electrical hazards are eliminated. For this assistance from the Public Works Maintenance Division will be sought.

6.3 NATURAL HAZARDS

Insect/animal bites and stings, poisonous plants, and inclement weather are natural hazards that may be present given the location of activities to be conducted. As previously discussed, this area is well maintained and therefore hazards of this nature are not considered predominant hazards. It should be noted that activities along the Canal may increase the potential to encounter snakes, insects - ticks, bees, mosquitoes, snakes, alligators, and poisonous vegetation.

For more information concerning these hazards see Section 4.0 of the HSGM. The following information is specific to the region and therefore not in the HSGM.

6.3.1 Snakes of Mississippi

The poisonous snakes found in Mississippi are the coral snake, cottonmouth or water moccasin, copperhead, and the pygmy, timber, and diamondback rattlesnakes. Initial efforts will be directed to avoid, where possible, nesting and territorial areas.

Coral Snake

Coral Snakes are extremely poisonous snakes with small, blunt heads and brightly colored bodies. They. They do not strike as effectively as other venomous snakes, but they bite. They are dangerous if stepped on or handled. The *eastern* coral snake generally ranges from 20 to 40 inches in length. Its body is encircled by broad black and red bands separated by narrow yellow ones. Just behind the snake's black snout is a wide yellow band followed by a black band. Some are covered with black pigment that hides much of the red color. Some nonpoisonous snakes look like coral snakes because they have similar coloring. But coral snakes have red bands next to yellow ones. The harmless snakes have red bands next to black ones.

Cotton Mouth or Water Moccasin

The water moccasin is a pit viper. It has a hollow, or pit, in the side of its head, between and slightly below the eye and nostril. Several harmless water snakes have a broad head like the moccasin, but they lack the pit. Adult water moccasins are about 3 ½ feet long, though some grow to more than 5 feet long. They usually have broad dark bands across their bodies. Water moccasins feed on a wide variety of animals, including frogs, fish, small mammals, and birds. Water moccasins are most often seen in watery places, in the swampy backwaters of rivers and streams, and on marshy lakeshores. The bite of the water moccasin is highly dangerous and may be fatal. This snake is also called a cottonmouth because when threatened it throws back its head and flashes its white-lined mouth as a warning signal.

Copperhead

Copperhead is also a poisonous pit vipers. Its body has broad chestnut-red bands. Most copperheads are about 2 ½ feet long while the largest grow to about 4 feet. The copperhead bites people more often than most rattlesnakes, partly because it is silent and smaller, and is not so quickly noticed. The bite is seldom fatal to adults. This reptile usually eats rodents and other small mammals by killing them with their poison and swallowing them whole. Sometimes the snake eats insects and frogs. The copperhead can be identified by the presence of a pit in front of and below each eye. The snake's nostril is in front of the pit.

Rattlesnake

The rattlesnake is a pit viper with a rattle on the end of its tail. The rattle is used to warn enemies to stay away. However, sometimes they give no warning before they bite. The rattlesnake always lifts its tail when it sounds where as harmless snakes that mimic the rattlesnake move their tail back and forth on top of dry leaves or grass.

The diamondback rattler is the heaviest of the poisonous snakes, though not the longest. It gets its name because diamond-shaped blotches edged with yellow cover its body. Diamondbacks rarely grow over feet long.

Pigmy rattlesnakes are short, relatively thick-bodied snakes. They have a dark line through the eye on each side of the face and a series of dark, roughly circular spots running down the center of the back. These dorsal spots interrupt a thin reddish-orange stripe that runs along the midbody line. Pigmy rattlesnakes first line of defense is to remain motionless. Their color pattern makes them hard to see in grass or leaf litter, especially when they are coiled. They almost never warn approaching people by sounding their rattle. They are likely to remain motionless until stepped on or over.

The Timber Rattlesnake has a large body and ranges in length of five to six feet. It has a broad triangular head, vertical pupils and heat sensitive pits. The body color may be yellow, gray, dark brown or black, with dark, V-shaped crossbands across the back. The head is usually unpatterned and is covered with many small scales. A distinct rattle on the end of a darkly colored tail produces a buzzing sound when vibrated.

Rattlesnakes send out poison through two long hollow fangs, in its upper jaw. The poison forms in a pair of glands behind each eye on the upper jaw. The rattlesnake's fangs are folded back in the mouth when not in use. When an angry rattlesnake strikes, the fangs are erected and the mouth opened wide. Most rattlesnakes eat birds, small mammals, amphibians and reptiles. The larger rattlers rank among the most dangerous of snakes and should be avoided

6.3.2 Snake Bite

However, should field personnel come in contact with these animals and receive a bite, the following actions are necessary:

- Obtain a detailed description of the snake. This and the bite mark will enable medical personnel administering medical aid to provide prompt and correct antidotes, as necessary.
- Immobilize the bite victim to the extent possible. Physical exertion will mobilize the toxins (if poisonous varieties) from the bite point systemically through the body.
- Apply a pressure wrap (for extremities), just above and over the bite area. With a couple wraps of the pressure wrap in place over the bite area, apply a splint, and continue the application of the pressure wrap. The purpose for the splint is to restrict the movement of the extremity, this along with the pressure wrap will aid in restricting the toxins from leaving the site of the bite.
- Seek medical attention immediately.

6.3.3 Inclement Weather

Project tasks under this Scope of Work will be performed outdoors. As a result, inclement weather may be encountered. In the event that adverse weather conditions arise (electrical storms, hurricanes, extreme heat and/or cold, etc.), the FOL and/or the SHSO will be responsible for temporarily suspending or terminating activities until hazardous conditions no longer exist.

Tropical Storms and Hurricanes

As the Gulfport Mississippi area is in a tropical storm, hurricane prone area, the following information is supplied to explain the potential severity of these natural hazards. The decision to curtail operations and evacuate the area should be made by the FOL, TOM, and the HSM.

During the early summer to late fall months, typically from the first of June through the end of November, disturbances migrating off the West Coast of Africa move into the Atlantic Ocean and develop into tropical cyclones known as tropical storms and hurricanes. Many of these cyclones become strong enough to threaten life and property along the Eastern Seaboard and Gulf Coast. There are three main threats associated with tropical storms and hurricanes:

- High winds
- Excessive rainfall
- Storm surge

The impacts of high winds and excessive rainfall occur hours, maybe days, before the tropical storm or hurricane makes landfall. However, the storm surge accompanies the storm or hurricane at the time that landfall occurs.

High Winds

Sustained winds vary greatly from storm to storm, but can range from 39 to 73 miles per hour (wind speeds associated with a tropical storm) to greater than 74 miles per hour (minimal wind speed for a Category 1 hurricane). The table below compares the type of storm or hurricane and the corresponding wind speed.

Table 6-2
TROPICAL STORM/HURRICANE RATING SCALE

TYPE	CATEGORY*	WINDS (MPH)
Tropical Depression	NA	>35-38
Tropical Storm	NA	39 – 73
Hurricane	1	74 – 95
Hurricane	2	96 – 110
Hurricane	3	111 – 130
Hurricane	4	131 – 155
Hurricane	5	>155

NA – Not Applicable

* Based on the Saffir-Simpson scale

In addition to strong winds, there is the threat of debris (i.e. building material, trees, etc.) becoming airborne projectiles as they are carried by the high winds. Thunderstorms and tornadoes embedded within the tropical storm or hurricane can further increase the wind speeds on a localized level.

Excessive Rainfall

Heavy rains associated with tropical storms and hurricanes also vary greatly from storm to storm. On average, an inch of rainfall an hour is not uncommon with major hurricanes, somewhat lesser amounts with tropical storms. However, the primary threat is not the intensity of rain, but the duration of rainfall. Since many tropical storms and hurricanes are slow-movers, they are capable of producing sustained heavy rainfall over a long period of time. It is not uncommon for an area to receive nearly 20 inches of rain in 24 hours. Under these conditions, street; stream and creek flooding is inevitable only to be exacerbated by locally heavier rains from thunderstorms.

Storm Surge

The storm surge is an abnormal rise in sea level accompanying a hurricane or tropical storm. The height of the storm surge (usually measured in feet) is the difference in sea level from the observed level (during the storm) and the level that would have occurred in the absence of the storm or hurricane. The more intense the storm or hurricane the higher the storm surge. Storm surges become even higher if they occur during periods of high tide.

The following table defines some of the terminology and possible calls to action regarding tropical cyclones:

Table 6-3
TROPICAL STORM/HURRICANE
WATCH AND WARNING

STORM DESCRIPTION	DEFINITION	ACTION
Tropical Storm Watch	Tropical storm conditions are possible in the specified area of the watch, usually within 36 hours	Weather conditions should be monitored for further advisories. Prepare for possible evacuation by local officials
Tropical Storm Warning	Tropical storm conditions are expected in the specified area of the warning, usually within 24 hours.	Work should be suspended in areas where lightning, high winds and rainfall could pose a threat to life. Mandatory evacuations may be enforced by local officials.
Hurricane Watch	Hurricane conditions are possible in the specified area of the watch, usually within 36 hours.	Weather conditions should be monitored for further advisories. Prepare for possible evacuation by local officials
Hurricane Warning	Hurricane conditions are expected in the specified area of the warning, usually within 24 hours.	Mandatory evacuations will most likely be enforced by local officials.

A NOAA Weather Radio is the best means to receive watches and warnings from the National Weather Service. The National Weather Service continuously broadcasts updated hurricane advisories that can be received by widely available NOAA Weather Radios.

7.0 HAZARD MONITORING – TYPES AND ACTION LEVELS

Direct reading instruments will be used at the sites to evaluate the presence of detectable site contaminants and other potentially hazardous conditions. As a result, specific air monitoring measures and requirements are established in Table 5-1 pertaining to the specific hazards and tasks of an identified operation. Additionally, the Health and Safety Guidance Manual, Section 1.0, contains detailed information regarding direct reading instrumentation, as well as general calibration procedures of various instruments.

7.1 INSTRUMENTS AND USE

Instruments will be used primarily to monitor source points and worker breathing zone areas, while observing instrument action levels. Action levels are discussed in Table 5-1 as they may apply to a specific task or location.

7.1.1 Photoionization Detector (PID)

In order to accurately monitor for any substances which may present an exposure potential to site personnel, a Photoionization Detector (PID) using a lamp energy of 10.6 eV or higher will be used. This instrument will be used to monitor potential source areas (boreholes, monitoring wells, free product recovery, etc.) and to screen the breathing zones of employees during site activities. The PID has been selected because it is most effective in detecting potential organic vapors of concern (vinyl chloride).

Prior to the commencement of any field activities, the background levels of the site must be determined and noted. Daily background readings will be taken away from any areas of potential contamination. These readings, any influencing conditions (i.e., weather, temperature, humidity) and site location must be documented in the field operations logbook or other site documentation (e.g., sample log sheet).

7.1.2 Hazard Monitoring Frequency

Table 5-1 presents the frequencies that hazard monitoring will be performed as well as the action levels which will initiate the use of elevated levels of protection. The SHSO may decide to increases these frequencies based on instrument responses and site observations. The frequency at which monitoring is performed will not be reduced without the prior consent of the PHSO or HSM.

7.2 INSTRUMENT MAINTENANCE AND CALIBRATION

Hazard monitoring instruments will be maintained and pre-field calibrated by the Tetra Tech NUS Equipment Manager and/or rental service employed. Operational checks and field calibration will be performed on the instruments each day prior to their use. Field calibration will be performed on instruments according to manufacturer's recommendations (for example, the PID must be field calibrated daily and an additional field calibration must be performed at the end of each day to determine any significant instrument drift). These operational checks and calibration efforts will be performed in a manner that complies with the employees health and safety training, the manufacturer's recommendations, and with the applicable manufacturer standard operating procedure. All calibration efforts must be documented. Figure 7-1 is provided for documenting these calibration activities. This information may instead be recorded in a field operations logbook, provided that the information specified in Figure 7-1 is recorded. This required information includes the following:

- Date calibration was performed
- Individual calibrating the instrument
- Instrument name, model, and serial number
- Any relevant instrument settings and resultant readings (before and after) calibration
- Identification of the calibration standard (lot no., source concentration, supplier)
- Any relevant comments or remarks

FIGURE 7-1

DOCUMENTATION OF FIELD CALIBRATION

SITE NAME: ____ **PROJECT NO.:**______________

Date of Calibration	Instrument Name and Model	Instrument I.D. Number	Person Performing Calibration	Instrument Settings		Instrument Readings		Calibration Standard (Lot Number)	Remarks/ Comments
				Pre-Calibration	Post-Calibration	Pre-Calibration	Post-Calibration		

8.0 TRAINING/MEDICAL SURVEILLANCE REQUIREMENTS

8.1 INTRODUCTORY/REFRESHER/SUPERVISORY TRAINING

This section specifies health and safety training and medical surveillance requirements for both Tetra Tech NUS and subcontractor personnel participating in on site activities.

8.1.1 Requirements For Tetra Tech NUS, Inc. and Subcontractor Personnel

Tetra Tech NUS and subcontractor personnel who will engage in field associated activities as described in this HASP must have:

- Completed 40 hours of introductory hazardous waste site training or equivalent work experience as defined in OSHA Standard 29 CFR 1910.120(e).
- Completed 8-Hour Refresher Training, if the identified persons had introductory training more than 12 months prior to site work.
- Completed 8-hour Supervisory training in accordance with 29 CFR 1910.120(e)(4), if their assigned function will involve the supervision of subordinate personnel.

Documentation of introductory training or equivalent work experience, supervisory, and refresher training as well as site-specific training will be maintained at the site. Copies of certificates or other official documentation will be used to fulfill this requirement.

8.2 SITE-SPECIFIC TRAINING

Tetra Tech NUS will provide site-specific training to Tetra Tech NUS employees and subcontractor personnel who will perform work on this project.

Figure 8-1 will be used to document the provision and content of the project-specific and associated training. Site personnel will be required to sign this form prior to commencement of site activities.

TtNUS will conduct a pre-activities training session prior to initiating site work. Additionally, a brief meeting will be held daily to discuss operations planned for that day. At the end of the workday, a short meeting may be held to discuss the operations completed and any problems encountered. This activity will be supported through the use of a Safe Work Permit System (See Section 10.2).

8.3 MEDICAL SURVEILLANCE

8.3.1 Medical Surveillance Requirements for Tetra Tech NUS and Subcontractor Personnel

Tetra Tech NUS and subcontractor personnel participating in project field activities will have had a physical examination. Physical examinations shall meet the minimum requirements of paragraph (f) of OSHA 29 CFR 1910.120. The physical examinations will be performed to ensure that personnel are medically qualified to perform hazardous waste site work using respiratory protection.

Documentation for medical clearances will be maintained at the job site and made available, as necessary. Subcontractor personnel may use an alternative documentation for this purpose. The "Subcontractor Medical Approval Form" can be used to satisfy this requirement, or a letter from an officer of the company. The letter should state that the persons listed in the letter participate in a medical surveillance program meeting the requirements contained in paragraph (f) of Title 29 of the Code of Federal Regulations (CFR), Part 1910.120, entitled "Hazardous Waste Operations and Emergency Response." The letter should further state the following:

- The persons listed have had physical examinations under this program within the frequency as determined sufficient by their occupational health care provider
- Date of the exam
- The persons identified have been cleared, by a licensed physician, to perform hazardous waste site work and to wear positive- and negative- pressure respiratory protection.

A sample Subcontractor Medical Approval Form and form letter have been provided to eligible subcontractors in the Bid Specification package.

8.3.2 Requirements for Field Personnel

Each field team member, including subcontractors and visitors, entering the exclusion zone(s) shall be required to complete and submit a copy of the Medical Data Sheet that is available in Attachment V of this HASP. This shall be provided to the SHSO, prior to participating in site activities. The purpose of this document is to provide site personnel and emergency responders with additional information that may be necessary in order to administer medical attention.

8.4 SUBCONTRACTOR EXCEPTION

If through the execution of their contract elements the subcontractor will not enter the exclusion zone and there is no potential for exposure to site contaminants, subcontractor personnel may be exempt from the training and medical surveillance requirements with the exception of Section 8.2. Examples of subcontractors who may qualify as exempt from training and medical surveillance requirements may include surveyors who perform surveying activities in site perimeter areas or areas were there is no potential for exposure to site contaminants and support or restoration services. **Use of this Subcontractor Exception is strictly limited to the authority of the CLEAN Health and Safety Manager.**

FIGURE 8-1

SITE-SPECIFIC TRAINING DOCUMENTATION

My signature below indicates that I am aware of the potential hazardous nature of performing field investigation activities at NCBC Gulfport, Mississippi and that I have received site-specific training that included the elements presented below:

- Names of designated personnel and alternates responsible for site safety and health
- Safety, health, and other hazards present on site
- Use of personal protective equipment
- Safe use of engineering controls and equipment
- Medical surveillance requirements
- Signs and symptoms of overexposure
- Contents of the Health and Safety Plan
- Emergency response procedures (evacuation and assembly points)
- Incipient response procedures
- Review of the contents of relevant Material Safety Data Sheets
- Review of the use of Safe Work Permits

I have been given the opportunity to ask questions and that my questions have been answered to my satisfaction and that the date of my training and my medical surveillance requirements indicated below are accurate.

Name (Printed and Signature)	Site-Specific Training Date	40-Hour Training (Date)	8-Hour Refresher Training (Date)	8-Hour Supervisory Training (Date)	Medical Exam

9.0 SPILL PREVENTION AND CONTAINMENT PROGRAM

9.1 SCOPE AND APPLICATION

This program applies to the single or aggregate accumulation of bulk storage materials (over 55-gallons). As the classification of certain materials such as IDW is unknown, these materials will be treated as hazardous, pending laboratory certification to the contrary. The types of materials for which this program will apply are as follows:

- Investigative Derived Wastes (IDW) such as decontamination fluids, soil cuttings, and purge and well development waters
- Resource Storage – Limited fuel and lubricant storage

The spill containment and control will be engaged any time there is a release of the above-identified materials from a containment system or vessel. This spill containment program will be engaged in order to minimize associated hazards.

9.2 POTENTIAL SPILL AREAS

Potential spill areas will be periodically monitored in an ongoing attempt to prevent and control further potential contamination of the environment. Currently, limited areas are vulnerable to this hazard including:

- Resource deployment
- Waste transfer
- Central staging

It is anticipated that the IDW generated as a result of this scope of work will be containerized, labeled, and staged to await further analyses. The results of these analyses will determine the method of disposal.

9.3 CONTAINMENT AREAS

In order to facilitate leak and spill inspection and response, and to minimize potential hazards which may impact the integrity of the storage containers, the staging area for these substances will be structured as follows:

9.3.1 IDW

- 55 Gallon Drums (United Nations 1A2 configurations) – 4 Drums to a Pallet; labels and the retaining ring bolt and nut on the outside of each drum to facilitate easy access; Minimum 4-feet between each row of pallets. The decision to construct a bermed and lined area will be the decision of project management .

- Storage Tank – Polyethylene Construction – Tank shall be placed into a bermed enclosure of sufficient size to accommodate 110% of anticipated volume (Largest container plus 10% for rainwater and container displacement).

Regardless of container types selected, the staging area will be identified as a Satellite Storage Area with proper signage, points of contact in the event of an emergency, alternate contacts, and identification of stored material (i.e., Purge or decontamination waters, soil cuttings, etc.).

An Inventory Log will be maintained by the FOL regarding types of IDW and volumes generated. An updated Inventory List will be provided by the FOL to the designated Emergency Response Agency or Base Contact during days off and between shifts or phases of operations.

9.3.2 Flammable/POL Storage

Flammable Storage [i.e., fuels, decontamination solvents (Isopropanol)] and Petroleum/oil/lubricants (POL) will require proper dispensing containers and necessary storage for cumulative volumes in excess of 25 gallons. Storage and dispensing will comply with the following requirements:

- The fuels, which will be stored and dispensed from portable containers, will utilize safety cans.
- Portable hand held storage containers will be labeled per Hazard Communication requirements.
- Larger volumes stored for fueling equipment will be stored in approved mobile Above Ground Storage Tanks with secondary containment capable of holding the tank volume plus 10%.
- Portable flammable liquid storage tanks will be properly grounded and will have bonding capabilities for the transfer of loading and off-loading of its contents.
- Dispensing locations will be supported by a Fire Extinguisher positioned no closer than 50 feet from the storage tank, properly mounted and identified.
- The storage location will be well marked with proper signage, protective bumper poles and will have straight through access/egress for vehicles.

9.4 MATERIALS HANDLING

To minimize the hazards associated with moving drums and containers (i.e, lifting, pinch and compression points) material handling will be supported in the following manner:

- A drum cart with pneumatic tires will be required, if drums are used for IDW storage. This cart will be used to relocate drums within the staging and satellite storage location.

- In addition, a mechanized means such as a suitably equipped skid loader or back-hoe will be provided to move IDW containers from the field location to the staging and satellite storage location. This piece of equipment will also be used in site clearance and restoration as deemed appropriate and necessary.

Other means of material handling will be evaluated by the SHSO based on their ability to minimize or eliminate material handling hazards.

9.5 LEAK AND SPILL DETECTION

To establish an early detection of potential spills or leaks, a periodic walk-around by the personnel staging or disposing of drums or in the Resource Deployment area will be conducted during working hours to visually determine that storage vessels are not leaking. If a leak is detected, the FOL will be notified and the Spill Containment/Control Response Plan as specified in Section 9.8 will be engaged. Inspections will be documented in the project logbook.

9.6 PERSONNEL TRAINING AND SPILL PREVENTION

Personnel will be instructed in the procedures for incipient spill prevention, containment, and collection of hazardous materials in the site-specific training. The FOL and/or the SHSO will serve as the Spill Response Coordinators for this operation, should the need arise. Personnel through the course of this project will be drilled as part of testing the EAP.

9.7 SPILL PREVENTION AND CONTAINMENT EQUIPMENT

The following represents the minimum equipment that will always be maintained at the staging areas the purpose of supporting this Spill Containment/Control Plan.

- Sand, clean fill, vermiculite, or other non combustible absorbent (Oil-dry)
- Extra Drums (55-gallon U.N. 1A2) should the need to transfer material from leaking containers arise.

- Pumps (Gas or Electric necessary for transferring liquids from leaking containers)/tubing
- Shovels, rakes, and brooms
- Container labels
- Personal Protective Equipment
  - Nitrile outer gloves
  - Splash Shield
  - Impermeable over-boots
  - Rain suit

9.8 SPILL CONTAINMENT/CONTROL RESPONSE PLAN

This section describes the procedures the Tetra Tech NUS field personnel will employ upon the detection of a spill or leak.

- Notify the SHSO or FOL immediately upon detection of a leak or spill. Activate emergency alerting procedures for that area to remove non-essential personnel.

- Employ the personal protective equipment stored at the staging area. Take immediate actions to stop the leak or spill by plugging or patching the container or raising the leak to the highest point in the vessel. Spread the absorbent material in the area of the spill, covering it completely.

- Transfer the material to a new vessel; collect and containerize the absorbent material. Label the new container appropriately. Await analyses for treatment and disposal options.

- Re-containerize spills, including 2-inch of top cover (if over soils) impacted by the spill. Await test results for treatment or disposal options.

It is not anticipated that a spill will occur that the field crew cannot handle. Should this occur, notification of the appropriate Emergency Response agencies will be carried out by the FOL or SSO in accordance with the procedures specified in Section 2.0 of this HASP.

10.0 SITE OPERATIONS AND CONTROL

Site operations and control will be facilitated through the use of established work zones and security and control of those zones. These activities will minimize the impact and spread of contaminants brought to the surface through subsurface investigative methods as well as protect personnel and visitors within these zones during ongoing operations.

10.1 WORK ZONES

Tetra Tech NUS will delineate and use work zones in conjunction with decontamination procedures to prevent the spread of contaminants to other areas of the site. A three-zone approach will be used for work at this site; an Exclusion Zone, a Contamination Reduction Zone, and a Support Zone. These will be used to control access to the work areas, restricting the general public, avoiding potentials to spread any contaminants, and to protect individuals who are not cleared to enter by way of training and/or medical surveillance qualifications.

10.1.1 Exclusion Zone

An Exclusion Zone will be established at each sampling point/location. The purpose of the exclusion zone is to define a area where a more rigorous protocol for workers within what is determined to be an impact area. The impact area is that area which could be adversely impacted by either chemical or physical hazards. Exclusion zone size and dimensions will vary based on activities. Impact areas dimensions will be influenced by the following considerations:

- Physical and topographical features of the site
- Weather conditions
- Field and analytical measurements of air and environmental contaminants
- Air dispersion calculations
- Potential for explosion and dispersion
- Physical, chemical and toxicological properties of the contaminants being investigated
- Tasks to be conducted
- Decontamination procedures
- Potential for exposure

As conditions change the dimensions of the exclusion zone will change. However, the following dimensions represent a starting point from which the exclusion zones will be expanded:

- DPT - Soil Boring. The exclusion zone for this activity will be set at the height of the mast, plus five feet surrounding the point of operation, with a minimum of 25-feet. This distance will also apply when subsurface soil sampling from behind these type rigs.

- HSA – Monitoring Well Installation. The exclusion zone for this activity will be set at the height of the mast, plus five feet surrounding the point of operation, or 35-feet, whichever is greater.

- Monitoring well development, sampling, aquifer testing. The exclusion zone for this activity will be set at 10-feet surrounding the well head and discharge collection container.

- Surface soils, sediment, and surface water sampling. The exclusion zone for this activity will be set at 5-feet surrounding the point of operation.

- Clearing and grubbing. The exclusion zone for this activity will be set at 10-feet surrounding someone with a brush hook or machete.

- Decontamination operation. The exclusion zone for this activity will be set at 25 feet surrounding the gross contamination wash and rinse as well as 25-feet surrounding the heavy equipment decontamination area.

- Investigative Derived Waste (IDW) area will be constructed and barricaded. Only authorized personnel will be allowed access.

Exclusion zones shall remain marked until the SHSO has evaluated the restoration effort and has authorized changing the zone status.

Exclusion zones will be marked using barrier tape, traffic cones and/or drive poles. Signs will be posted to inform and direct site personnel and site visitors.

10.1.2 Contamination Reduction Zone

The contamination reduction zone will be split to represent two separate functions. The first function will be a control/supply point for supporting exclusion zone activities. The second function, which may take place a sufficient distance from the exclusion zone is the decontamination of personnel and heavy equipment.

In order to move from the exclusion zone to a separate location the following activities will be used:

- As samplers move from location to location during sampling activities, dedicated sampling devices and PPE will be washed of gross contamination, removed, separated, and bagged. Personnel will use hygienic wipes, such as Handy Wipes, as necessary for personnel decontamination until they can access the centralized decontamination unit. At the first available opportunity personnel will wash their face and hands. This is critical prior to breaks and lunch when contamination can be transferred to the mouth through hand to mouth contact.

- Muddy over-boots and gloves may be required to go through a gross contamination wash at the exclusion zone. These items will then be cleaned thoroughly at the centralized decontamination unit.

- Potentially contaminated tooling along with PPE will be wrapped, when necessary, for transport to the decontamination area. These items will be disposed of as general refuse.

- Upon completion of the assigned tasks the personnel will move through the central decontamination area to clean reusable PPE and field equipment. Based on ambient conditions medical evaluations may take place at the termination point of the decontamination line. These evaluations will include pulse rate, oral temperature, breathing rate to evaluate physiological demands on site personnel. As stated earlier, these evaluations will be based on ambient conditions and acclimation periods.

10.1.3 <u>Support Zone</u>

The Support Zone will consist of a field trailer, storage, lay-down areas, or some other uncontaminated, controlled point. The Support Zone for this project will include a staging area where site vehicles can be parked, equipment will be unloaded, and where food and drink containers will be maintained. The support zones will be established in clean areas of the site.

10.2 SAFE WORK PERMITS

Exclusion Zone work conducted in support of this project will be performed using Safe Work Permits to guide and direct field crews on a task by task basis. An example of the Safe Work Permit is included in Figure 10-1. The daily meetings conducted by the FOL/SHSO will further support these work permits. The use of these permits will ensure that site-specific considerations and changing conditions are incorporated into the planning effort. Safe Work Permits will require the signatures of either the FOL or the SHSO.

Personnel engaged in on-site activities must be made aware of the elements indicating levels of protection and precautionary measures to be used.

The use of these permits will establish and provide for reviewing protective measures and hazards associated with each operation. This HASP will be used as the primary reference for selecting levels of protection and control measures. The Safe Work Permit will take precedence over the HASP when more conservative measures are required based on specific site conditions.

Upon completion of the work for which the Safe Work Permit was assigned, the Safe Work Permit will be turned into the FOL or the SHSO. Concerns, complaints, and suggestions may be made on the reverse of the Safe Work Permit for consideration by the FOL and/or the SHSO. Permits turned in with suggestions, difficulties, or complaints will be forwarded to the PHSO for review.

The Safe Work Permit and the HASP will serve as the primary reference for work place evaluations and audits conducted to determine if the task is being conducted under the direction conveyed by the HASP and the Safe Work Permit.

10.3 SITE MAP

Once the areas of contamination, access routes, topography, dispersion routes are determined, a site map will be generated and adjusted as site conditions change. This map will be posted to illustrate up-to-date information of contaminants and adjustment of zones and access points. This map will be posted at the field support trailer.

10.4 BUDDY SYSTEM

Personnel engaged in on-site activities will practice the "buddy system" to ensure the safety of the personnel involved in this operation.

FIGURE 10-1
SAFE WORK PERMIT

Permit No. __________ Date: __________ Time: From ______ to ____

SECTION I: General Job Scope (To be filled in by person performing work)

I. Work limited to the following (description, area, equipment used): ____________________

II. Names: ____________________

III. On-site Inspection conducted ☐ Yes ☐ No Initials of Inspector __________ ______
TtNUS

SECTION II: General Safety Requirements (To be filled in by permit issuer)

IV. Protective equipment required

Level D ☐ Level B ☐
Level C ☐ Level A ☐

Respiratory equipment required

Full face APR ☐ Escape Pack ☐
Half face APR ☐ SCBA ☐
PAPR ☐ Bottle Trailer ☐
Skid Rig ☐ None ☐

Modifications/Exceptions: ____________________

V. Chemicals of Concern | Action Level(s) | Response Measures

VI. Additional Safety Equipment/Procedures

Hardhat ☐ Yes ☐ No
Safety Glasses ☐ Yes ☐ No
Chemical/splash goggles ☐ Yes ☐ No
Splash Shield ☐ Yes ☐ No
Splash suit/coveralls (Type:_____) ☐ Yes ☐ No
Steel toe/shank Workboots ☐ Yes ☐ No
Hearing Protection (Plugs/Muffs) ☐ Yes ☐ No
Safety belt/harness ☐ Yes ☐ No
Radio ☐ Yes ☐ No
Barricades ☐ Yes ☐ No
Gloves (Type) ☐ Yes ☐ No
Work/rest regimen ☐ Yes ☐ No
Chemical Protective Over-boots (Type:______) ☐ Yes ☐ No

Modifications/Exceptions: ____________________

VII. Procedure review with permit acceptors

	Yes	NA
Safety shower/eyewash (Location & Use)	☐	☐
Procedure for safe job completion	☐	☐
Contractor tools/equipment inspected	☐	☐
Emergency alarms	☐	☐
Evacuation routes	☐	☐
Assembly points	☐	☐

VII. Site Preparation

	Yes	No	NA
Utility Locating and Excavation Clearance completed	☐	☐	☐
Equipment and Foot Traffic Routes Cleared and Established	☐	☐	☐

Physical Hazards Barricaded and Isolated	☐	☐	☐
Emergency Equipment Staged	☐	☐	☐

VIII. Additional Permits required (Hot work, confined space entry, excavation, etc.). ☐ Yes ☐ No
If yes, See SHSO for appropriate permit

IX. Special instructions, precautions: ____________________

Permit Issued by: ____________________ Permit Accepted by: ____________________

10.5 MATERIAL SAFETY DATA SHEET (MSDS) REQUIREMENTS

Tetra Tech NUS personnel will provide MSDSs for chemicals brought on-site. The contents of these documents will be reviewed by the SHSO with the user(s) of the chemical substances prior to any actual use or application or the substances on-site. The MSDSs will be maintained in a central location (i.e., temporary office) and will be available for anyone to review upon request. The SHSO will be responsible for implementing a site-specific Hazard Communication Program (See Section 5.0 of the TtNUS Health and Safety Guidance Manual). This includes collection of MSDSs, creation and maintenance of an accurate Chemical Inventory Listing, addressing container labeling and personnel training issues, and other aspects of Hazard Communication.

10.6 COMMUNICATION

It is anticipated that site personnel will be working in close proximity during proposed field activities. In the event that site personnel are in isolated areas or are separated by significant distances, a supported means of communication between field crews will be utilized. Two-way radio communication devices, if needed, will be used only with NCBC Gulfport approval.

External communications will be accomplished utilizing telephones at predetermined and approved locations or through cellular phones. External communication will primarily be used for the purpose of resource and emergency resource communications. Prior to the commencement of site activities, the FOL will determine and arrange for telephone communications, if it is determined a cellular means will not be used.

10.7 SITE VISITORS

Potential site visitors that may be encountered during the performance of the field work could include the following:

- Personnel invited to observe or participate in operations by Tetra Tech NUS.
- Regulatory personnel (i.e., DOD, MDEQ, EPA, OSHA, etc.)
- Southern Division Navy personnel
- Other authorized visitors

Non-DOD personnel working on this project are required to gain initial access to the base by coordinating with the TtNUS TOM or designee and following established base access procedures.

Once access to the base is obtained, personnel who require access to Tetra Tech NUS work sites (areas of ongoing operations) will be required to obtain permission from the FOL and the Base Contact. Upon gaining access to the work site, site visitors wishing to observe operations in progress will be required to meet the minimum requirements as stipulated below.

- Site visitors will be routed to the FOL, who will sign them into the field logbook. Information to be recorded in the logbook will include the individuals name (proper identification required), who they represent, and the purpose for the visit. The FOL is responsible for ensuring that site visitors are always escorted while on site.

- Site visitors will be required to produce the necessary information supporting clearance on to the site. This includes information attesting to applicable training (40-hours of HAZWOPER training required for Southern Division Navy Personnel), and medical surveillance as stipulated in Section 8.3, of this document. In addition, to enter the sites operational zones during planned activities, visitors will be required to first go through site-specific training covering the topics stipulated in Section 8.2 of this HASP.

Once the site visitors have completed the above items they will be permitted to enter the site and applicable operational areas. Visitors are required to observe the protective equipment and site restrictions in effect at the work areas visited. Any visitors not meeting the requirements as stipulated in this plan for site clearance will not be permitted to enter the site operational zones during planned activities. Any incidence of unauthorized site visitation will cause on-site activities to be terminated until that visitor can be removed. Removal of unauthorized visitors will be accomplished with support form the Base Contact, if necessary. At a minimum, the Base Contact will be notified of any unauthorized visitors.

10.8 SITE SECURITY

As this activity will take place at a Navy facility, the first line of security will be provided by the base gate restricting the general public. The second line of security will take place at the work site referring interested parties to the FOL and Base Contact.

Security at the work areas will be accomplished using field personnel. This is a multiple person operation, involving multiple operational zones. Tetra Tech NUS personnel will retain complete control over active operational zones.

The Base Contact will serve as the focal point for base personnel and interested parties and will serve as the primary enforcement contact.

10.9 SANITATION AND BREAK AREAS

This section will address the following items:

- Toilets
- Potable water
- Showers and change rooms
- Break Areas

10.9.1 Toilets

One toilet will be provided for every 20 people. All toilets will be unisex and will have locking doors. The toilet provided will either be a chemical toilet and service provider or the flush toilet readily accessible at a predetermined approved location.

- TtNUS Field Trailer - Port-a-John at the staging area.

10.9.2 Potable Water

Potable water as well as electrolyte balance sports drinks such as Gatorade will be provided to the field crews for fluid replacement, as it is necessary under conditions of ambient temperature extremes. Storage and dispensing will proceed as follows:

- All containers will be clean and replenished daily.

- All containers will clearly marked as to their contents (Potable Water – Drinking Water Only; Gatorade, etc.).

- Dispensing locations will be placed in identified break areas within the support zone. The most likely location will be at a support vehicle staged near the work area. This will serve as an area for cooling or warming as well as an identified food and drink consumption area.

- If larger containers are used, dispensing cups will be provided.

- The coolers used for storage of potable drinks and cups will be stored in plastic bags away from potentially contaminating materials when not in use.

Fluid intake recommendations may be made based on the medical evaluations conducted at the end of the decontamination process, as necessary based on ambient conditions.

10.9.3 Showers and Change Rooms

Based on this scope and duration of this project shower facilities and locker rooms will not be required.

10.9.4 Break Areas

Given the location and the time of the year structured suitable locations for work breaks and warming/cooling regimens will be necessary. Shelters such as canopies should be provided for protection from the sun as well as to provide a suitable area to permit cooling in this hot environment.

11.0 CONFINED SPACE ENTRY

It is not anticipated, under the proposed scope of work, that confined space and permit-required confined space activities will be conducted. **Therefore, personnel under the provisions of this HASP are not allowed, under any circumstances, to enter confined spaces**. A confined space is defined as an area which has the following characteristics:

- Is large enough and so configured that an employee can bodily enter and perform assigned work.
- Has limited or restricted means for entry or exit (for example, tanks, vessels, silos, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry).
- Is not designed for continuous employee occupancy.

A Permit-Required Confined Space is one that:

- Contains or has a potential to contain a hazardous atmosphere.
- Contains a material that has the potential to engulf an entrant.
- Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor which slopes downward and tapers to a smaller cross-section.
- Contains any other recognized, serious, safety or health hazard.

For further information on confined space, consult the Health and Safety Guidance Manual or call the PHSO. If confined space operations are to be performed as part of the scope of work, detailed procedures and training requirements will have to be addressed, and the HSM will have to be notified.

12.0 MATERIALS AND DOCUMENTATION

The TtNUS FOL shall ensure the following materials/documents are taken to the project site and used when required.

- A complete copy of this HASP
- Health and Safety Guidance Manual
- Incident Reports
- Medical Data Sheets
- Material Safety Data Sheets for chemicals brought on site, including decontamination solutions, fuels, sample preservatives, calibration gases, etc.
- A full-size OSHA Job Safety and Health Poster (posted in the site trailers)
- Training/Medical Surveillance Documentation Form (Blank)
- Emergency Reference Information (Section 2.0, extra copy for posting)

12.1 MATERIALS TO BE POSTED OR MAINTAINED AT THE SITE

The following documentation is to be posted or maintained at the site for quick reference purposes. In situations where posting these documents is not feasible, (such as no office trailer), these documents should be separated and immediately accessible.

Chemical Inventory Listing (posted) - This list represents chemicals brought on-site, including decontamination solutions, sample preservations, fuel, etc.. This list should be posted in a central area.

MSDSs (maintained) - The MSDSs should also be in a central area accessible to site personnel. These documents should match the listings on the chemical inventory list for substances used on-site. It is acceptable to have these documents within a central folder and the chemical inventory as the table of contents.

The OSHA Job Safety & Health Protection Poster (posted) - this poster, as directed by 29 CFR 1903.2 (a)(1), should be conspicuously posted in places where notices to employees are normally posted. Each FOL shall ensure that this poster is not defaced, altered, or covered by other material.

Site Clearance (maintained) - This list is found within the training section of the HASP (See Figure 8-2). This list identifies site personnel, dates of training (including site-specific training), and medical surveillance. The lists indicates not only clearance but also status. If personnel do not meet these requirements, they do not enter the site while site personnel are engaged in activities.

Emergency Phone Numbers and Directions to the Hospital(s) (posted) - This list of numbers and directions will be maintained at the phone communications points and in each site vehicle.

Medical Data Sheets/Cards (maintained) - Medical Data Sheets will be filled out by on-site personnel and filed in a central location. The Medical Data Sheet will accompany any injury or illness requiring medical attention to the medical facility. A copy of this sheet or a wallet card will be given to personnel to be carried on their person.

Hearing Conservation Standard (29 CFR 1910.95) (posted) - this standard will be posted anytime hearing protection or other noise abatement procedures are employed.

Personnel Monitoring (maintained) - The results generated through personnel sampling (levels of airborne toxins, noise levels, etc.) will be posted to inform individuals of the results of that effort.

Placards and Labels (maintained) - Where chemical inventories have been separated because of quantities and incompatibilities, these areas will be conspicuously marked using Department of Transportation (DOT) placards and acceptable (Hazard Communication 29 CFR 1910.1200(f)) labels.

The purpose of maintaining or posting this information, as stated above, is to allow site personnel quick access. Variations concerning location and methods of presentation are acceptable, providing the objection is accomplished.

13.0 GLOSSARY

ACGIH	American Conference of Governmental Industrial Hygienists
APR	Air Purifying Respirators
AOC	Area of Concern
CERCLA	Comprehensive Environmental Response Compensation, and Liability Act
CFR	Code of Federal Regulations
CNS	Central Nervous System
CRZ	Contamination Reduction Zone
CTO	Contract Task Order
DOD	Department of Defense
DOT	Department of Transportation
DPT	Direct-Push Technology
EPA	Environmental Protection Agency
FFA	Federal Facilities Agreement
eV	Electron Volts
FID	Flame Ionization Detector
FOL	Field Operations Leader
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
HEPA	High Efficiency Particulate Air
HSM	Health and Safety Manager
IDW	Investigation-derived Waste
LEL/O_2	Lower Explosive Limit/Oxygen
MSDS	Material Safety Data Sheet
N/A	Not Available
NAS	Naval Air Station
NIOSH	National Institute Occupational Safety and Health
NPL	National Priorities List
OSHA	Occupational Safety and Health Administration (U.S. Department of Labor)
PEL	Permissible Exposure Limit
PHSO	Project Health and Safety Officer
PID	Photo Ionization Detector
PM	Project Manager
PPE	Personal Protective Equipment
RIFS	Remedial Investigation and Feasibility Study

SAP	Sampling and Analysis Plan
SCBA	Self Contained Breathing Apparatus
SOPs	Standard Operating Procedures
SHSO	Site Health and Safety Officer
STEL	Short Term Exposure Limit
SVOC	Semi-volatile Organic Compounds
TOM	Task Order Manager
TPH	Total Petroleum Hydrocarbons
TtNUS	Tetra Tech NUS, Inc.
TWA	Time Weighted Average
USTs	Underground Storage Tanks
UV	Ultra Violet
VOCs	Volatile Organic Compounds

ATTACHMENT I

INJURY/ILLNESS PROCEDURE AND REPORT FORM

TETRA TECH NUS, INC.

INJURY/ILLNESS PROCEDURE
WORKER'S COMPENSATION PROGRAM

WHAT YOU SHOULD DO IF YOU ARE INJURED OR DEVELOP AN ILLNESS AS A RESULT OF YOUR EMPLOYMENT:

- If injury is minor, obtain appropriate first aid treatment.
- If injury or illness is severe or life threatening, obtain professional medical treatment at the nearest hospital emergency room.
- If incident involves a chemical exposure on a project work site, follow instructions in the Health & Safety Plan.
- Immediately report any injury or illness to your supervisor or office manager. In addition, you must contact your Human Resources representative, Marilyn Duffy at (412) 921-8475, and the Corporate Health and Safety Manager, Matt Soltis at (412) 921-8912 within 24 hours. You will be required to complete an Injury/Illness Report (attached). You may also be required to participate in a more detailed investigation from the Health Sciences Department.
- If further medical treatment is needed, The Hartford Network Referral Unit will furnish a list of network providers customized to the location of the injured employee. These providers are to be used for treatment of Worker's Compensation injuries subject to the laws of the state in which you work. Please call Marilyn Duffy at (412) 921-8475 for the number of the Referral Unit.

ADDITIONAL QUESTIONS REGARDING WORKER'S COMPENSATION:

Contact your local human resources representative, corporate health and safety coordinator, or Corporate Administration in Pasadena, California, at (626) 351-4664.

Worker's compensation is a state-mandated program that provides medical and disability benefits to employees who become disabled due to job related injury or illness. Tetra Tech, Inc. and its subsidiaries (Tetra Tech or Company) pay premiums on behalf of their employees. The type of injuries or illnesses covered and the amount of benefits paid are regulated by the state worker's compensation boards and vary from state to state. Corporate Administration in Pasadena is responsible for administering the Company's worker's compensation program. The following is a general explanation of worker's compensation provided in the event that you become injured or develop an illness as a result of your employment with Tetra Tech or any of its subsidiaries. Please be aware that the term used for worker's compensation varies from state to state.

WHO IS COVERED:

All employees of Tetra Tech, whether they are on a full-time, part-time or temporary status, working in an office or in the field, are entitled to worker's compensation benefits. All employees must follow the above injury/illness reporting procedures. Consultants, independent contractors, and employees of subcontractors are <u>not</u> covered by Tetra Tech's Worker's Compensation plan.

TETRA TECH NUS, INC.
INJURY/ILLNESS PROCEDURE
WORKER'S COMPENSATION PROGRAM

WHAT IS COVERED:

If you are injured or develop an illness caused by your employment, worker's compensation benefits are available to you subject to the laws of the state you work in. Injuries do not have to be serious; even injuries treated by first aid practices are covered and must be reported. Please note that if you are working out-of-state and away from your home office, you are still eligible for worker's compensation benefits.

ATTACHMENT II

STANDARD OPERATING PROCEDURE
FOR
UTILITY LOCATING AND EXCAVATION CLEARANCE

TETRA TECH NUS, INC.	STANDARD OPERATING PROCEDURES	Number HS-1.0	Page 1 of 15
		Effective Date 12/03	Revision 2
		Applicability Tetra Tech NUS, Inc.	
		Prepared Health & Safety	
Subject UTILITY LOCATING AND EXCAVATION CLEARANCE		Approved D. Senovich	

TABLE OF CONTENTS

1.0 PURPOSE

Utilities such as electric service lines, natural or propane gas lines, water and sewage lines, telecommunications, and steam lines are very often in the immediate vicinity of work locations. Contact with underground or overhead utilities can have serious consequences including employee injury/fatality, property and equipment damage, substantial financial impacts, and loss of utility service to users.

The purpose of this procedure is to provide minimum requirements and technical guidelines regarding the appropriate procedures to be followed when performing subsurface and overhead utility locating services. It is the policy of Tetra Tech NUS, Inc. (TtNUS) to provide a safe and healthful work environment for the protection of our employees. The purpose of this Standard Operating Procedure (SOP) is to aid in achieving the objectives of this policy, to present the acceptable procedures pertaining to utility locating and excavation clearance activities, and to present requirements and restrictions relevant to these types of activities. This SOP must be reviewed by any employee potentially involved with underground or overhead utility locating and avoidance activities.

2.0 SCOPE

This procedure applies to all TtNUS field activities where there may be potential contact with underground or overhead utilities. This procedure provides a description of the principles of operation, instrumentation, applicability, and implementability of typical methods used to determine the presence and avoidance of contact with utility services. This procedure is intended to assist with work planning and scheduling, resource planning, field implementation, and subcontractor procurement. Utility locating and excavation clearance requires site-specific information prior to the initiation of any such activities on a specific project. This SOP is not intended to provide a detailed description of methodology and instrument operation. Specialized expertise during both planning and execution of several of the methods presented may also be required.

3.0 GLOSSARY

Electromagnetic Induction (EMI) Survey - A geophysical exploration method whereby electromagnetic fields are induced in the ground and the resultant secondary electromagnetic fields are detected as a measure of ground conductivity.

Magnetometer – A device used for precise and sensitive measurements of magnetic fields.

Magnetic Survey – A geophysical survey method that depends on detection of magnetic anomalies caused by the presence of buried ferromagnetic objects.

Metal Detection – A geophysical survey method that is based on electromagnetic coupling caused by underground conductive objects.

Vertical Gradiometer – A magnetometer equipped with two sensors that are vertically separated by a fixed distance. It is best suited to map near surface features and is less susceptible to deep geologic features.

Ground Penetrating Radar – Ground Penetrating Radar (GPR) involves specialized radar equipment whereby a signal is sent into the ground via a transmitter. Some portion of the signal will be reflected from the subsurface material, which is then recorded with a receiver and electronically converted into a graphic picture.

4.0 RESPONSIBILITIES

Project Manager (PM)/Task Order Manager (TOM) - Responsible for ensuring that all field activities are conducted in accordance with this procedure.

Site Manager (SM)/Field Operations Leader (FOL) - Responsible for the onsite verification that all field activities are performed in compliance with approved SOPs or as otherwise directed by the approved project plan(s).

Site Health & Safety Officer (SHSO) – Responsible to provide technical assistance and verify full compliance with this SOP. The SHSO is also responsible for reporting any deficiencies to the Corporate Health and Safety Manager (HSM) and to the PM/TOM.

Health & Safety Manager (HSM) – Responsible for preparing, implementing, and modifying corporate health and safety policy and this SOP.

Site Personnel – Responsible for performing their work activities in accordance with this SOP and the TtNUS Health and Safety Policy.

5.0 PROCEDURES

This procedure addresses the requirements and technical procedures that must be performed to minimize the potential for contact with underground and overhead utility services. These procedures are addressed individually from a buried and overhead standpoint.

5.1 Buried Utilities

Buried utilities present a heightened concern because their location is not typically obvious by visual observation, and it is common that their presence and/or location is unknown or incorrectly known on client properties. This procedure must be followed prior to beginning any subsurface probing or excavation that might potentially be in the vicinity of underground utility services. In addition, the Utility Clearance Form (Attachment 3) must be completed for every location or cluster of locations where intrusive activities will occur.

Where the positive identification and de-energizing of underground utilities cannot be obtained and confirmed using the following steps, the PM/TOM is responsible for arranging for the procurement of a qualified, experienced, utility locating subcontractor who will accomplish the utility location and demarcation duties specified herein.

1. A comprehensive review must be made of any available property maps, blue lines, or as-builts prior to site activities. Interviews with local personnel familiar with the area should be performed to provide additional information concerning the location of potential underground utilities. Information regarding utility locations shall be added to project maps upon completion of this exercise.

2., A visual site inspection must be performed to compare the site plan information to actual field conditions. Any findings must be documented and the site plan/maps revised. The area(s) of proposed excavation or other subsurface activities must be marked at the site in white paint or pin flags to identify those locations of the proposed intrusive activities. The site inspection should focus on locating surface indications of potential underground utilities. Items of interest include the presence of nearby area lights, telephone service, drainage grates, fire hydrants, electrical service vaults/panels, asphalt/concrete scares and patches, and topographical depressions. Note the location of any emergency shut off switches. Any additional information regarding utility locations shall be added to project maps upon completion of this exercise and returned to the PM/TOM.

3. If the planned work is to be conducted on private property (e.g., military installations, manufacturing facilities, etc.) the FOL must identify and contact appropriate facility personnel (e.g., public works or facility engineering) before any intrusive work begins to inquire about (and comply with) property owner requirements. It is important to note that private property owners may require several days to several weeks advance notice prior to locating utilities.

4. If the work location is on public property, the state agency that performs utility clearances must be notified (see Attachment 1). State "one-call" services must be notified prior to commencing fieldwork per their requirements. Most one-call services require, by law, 48- to 72-hour advance notice prior to beginning any excavation. Such services typically assign a "ticket" number to the particular site. This ticket number must be recorded for future reference and is valid for a specific period of time, but may be extended by contacting the service again. The utility service will notify utility representatives who then mark their respective lines within the specified time frame. It should be noted that most military installations own their own utilities but may lease service and maintenance from area providers. Given this situation, "one call" systems may still be required to provide location services on military installations.

5. Utilities must be identified and their locations plainly marked using pin flags, spray paint, or other accepted means. The location of all utilities must be noted on a field sketch for future inclusion on project maps. Utility locations are to be identified using the following industry-standard color code scheme, unless the property owner or utility locator service uses a different color code:

white	excavation/subsurface investigation location
red	electrical
yellow	gas, oil, steam
orange	telephone, communications
blue	water, irrigation, slurry
green	sewer, drain

6. Where utility locations are not confirmed with a high degree of confidence through drawings, schematics, location services, etc., the work area must be thoroughly investigated prior to beginning the excavation. In these situations, utilities must be identified using safe and effective methods such as passive and intrusive surveys, or the use of non-conductive hand tools. Also, in situations where such hand tools are used, they should always be used in conjunction with suitable detection equipment, such as the items described in Section 6.0 of this SOP. Each method has advantages and disadvantages including complexity, applicability, and price. It also should be noted that in some states, initial excavation is required by hand to a specified depth.

7. At each location where trenching or excavating will occur using a backhoe or other heavy equipment, and where utility identifications and locations cannot be confirmed prior to groundbreaking, the soil must be probed using a device such as a tile probe which is made of non-conductive material such as fiberglass. If these efforts are not successful in clearing the excavation area of suspect utilities, hand shoveling must be performed for the perimeter of the intended excavation.

8. All utilities uncovered or undermined during excavation must be structurally supported to prevent potential damage. Unless necessary as an emergency corrective measure, TtNUS shall not make any repairs or modifications to existing utility lines without prior permission of the utility owner, property owner, and Corporate HSM. All repairs require that the line be locked-out/tagged-out prior to work.

5.2 Overhead Power Lines

If it is necessary to work within the minimum clearance distance of an overhead power line, the overhead line must be de-energized and grounded, or re-routed by the utility company or a registered electrician. If protective measures such as guarding, isolating, or insulating are provided, these precautions must be adequate to prevent employees from contacting such lines directly with any part of their body or indirectly though conductive materials, tools, or equipment.

The following table provides the required minimum clearances for working in proximity to overhead power lines.

Nominal Voltage	Minimum Clearance
0 -50 kV	10 feet, or one mast length; whichever is greater
50+ kV	10 feet plus 4 inches for every 10 kV over 50 kV or 1.5 mast lengths; whichever is greater

6.0 UNDERGROUND LOCATING TECHNIQUES

A variety of supplemental utility locating approaches are available and can be applied when additional assurance is needed. The selection of the appropriate method(s) to employ is site-specific and should be tailored to the anticipated conditions, site and project constraints, and personnel capabilities.

6.1 Geophysical Methods

Geophysical methods include electromagnetic induction, magnetics, and ground penetrating radar. Additional details concerning the design and implementation of electromagnetic induction, magnetics, and ground penetrating radar surveys can be found in one or more of the TtNUS SOPs included in the References (Section 8.0).

Electromagnetic Induction

Electromagnetic Induction (EMI) line locators operate either by locating a background signal or by locating a signal introduced into the utility line using a transmitter. A utility line acts like a radio antenna, producing electrons, which can be picked up with a radiofrequency receiver. Electrical current carrying conductors have a 60HZ signal associated with them. This signal occurs in all power lines regardless of voltage. Utilities in close proximity to power lines or used as grounds may also have a 60HZ signal, which can be picked up with an EM receiver. A typical example of this type of geophysical equipment is an EM-61.

EMI locators specifically designed for utility locating use a special signal that is either indirectly induced onto a utility line by placing the transmitter above the line or directly induced using an induction clamp. The clamp induces a signal on the specific utility and is the preferred method of tracing since there is little chance of the resulting signals being interfered with. A good example of this type of equipment is the Schonstedt® MAC-51B locator. The MAC-51B performs inductively traced surveys, simple magnetic locating, and traced nonmetallic surveys.

When access can be gained inside a conduit to be traced, a flexible insulated trace wire can be used. This is very useful for non-metallic conduits but is limited by the availability of gaining access inside the pipe.

Magnetics

Magnetic locators operate by detecting the relative amounts of buried ferrous metal. They are incapable of locating or identifying nonferrous utility lines but can be very useful for locating underground storage tanks (UST's), steel utility lines, and buried electrical lines. A typical example of this type of equipment is the Schonstedt® GA-52Cx locator. The GA-52Cx is capable of locating 4-inch steel pipe up to 8 feet deep.

Non-ferrous lines are often located by using a typical plumbing tool (snake) fed through the line. A signal is then introduced to the snake that is then traced.

Ground Penetrating Radar

Ground Penetrating Radar (GPR) involves specialized radar equipment whereby a signal is sent into the ground via a transmitter. Some portion of the signal will be reflected from the subsurface material, which is then recorded with a receiver and electronically converted into a graphic picture. In general, an object which is harder than the surrounding soil will reflect a stronger signal. Utilities, tunnels, UST's, and footings will reflect a stronger signal than the surrounding soil. Although this surface detection method may determine the location of a utility, this method does not specifically identify utilities (i.e., water vs. gas, electrical vs. telephone); hence, verification may be necessary using other methods. This method is somewhat limited when used in areas with clay soil types or with a high water table.

6.2 Passive Detection Surveys

Acoustic Surveys

Acoustic location methods are generally most applicable to waterlines or gas lines. A highly sensitive Acoustic Receiver listens for background sounds of water flowing (at joints, leaks, etc.) or to sounds introduced into the water main using a transducer. Acoustics may also be applicable to determine the location of plastic gas lines.

Thermal Imaging

Thermal (i.e., infrared) imaging is a passive method for detecting the heat emitted by an object. Electronics in the infrared camera convert subtle heat differentials into a visual image on the viewfinder or a monitor. The operator does not look for an exact temperature; rather they look for heat anomalies (either elevated or suppressed temperatures) characteristic of a potential utility line.

The thermal fingerprint of underground utilities results from differences in temperature between the atmosphere and the fluid present in a pipe or the heat generated by electrical resistance. In addition, infrared scanners may be capable of detecting differences in the compaction, temperature and moisture content of underground utility trenches. High-performance thermal imagery can detect temperature differences to hundredths of a degree.

6.3 Intrusive Detection Surveys

Vacuum Excavation

Vacuum excavation is used to physically expose utility services. The process involves removing the surface material over approximately a 1' x 1' area at the site location. The air-vacuum process proceeds with the simultaneous action of compressed air-jets to loosen soil and vacuum extraction of the resulting debris. This process ensures the integrity of the utility line during the excavation process, as no hammers, blades, or heavy mechanical equipment comes into contact with the utility line, eliminating the risk of damage to utilities. The process continues until the utility is uncovered. Vacuum excavation can be used at the proposed site location to excavate below the "utility window" which is usually 8 feet.

Hand Excavation

When the identification and location of underground utilities cannot be positively confirmed through document reviews and/or other methods, borings and excavations may be cleared via the use of non-conductive hand tools. This should always be done in conjunction with the use of detection equipment. This would be required for all locations where there is a potential to impact buried utilities. The minimum hand-excavation depth that must be reached is to be determined considering the geographical location of the work site. This approach recognizes that the placement of buried utilities is influenced by frost line depths that vary by geographical region. Attachment 2 presents frost line depths for the regions of the contiguous United States. At a minimum, hand excavation depths must be at least to the frost line depth (see Attachment 2) plus two (2) feet, but never less than 4 feet below ground surface (bgs). For hand excavation, the hole created must be reamed large enough to be at least the diameter of the drill rig auger or bit prior to drilling. For soil gas surveys, the survey probe shall be placed as close as possible to the cleared hand excavation. It is important to note that a post-hole digger must not be used in this type of hand excavation activity.

Tile Probe Surveys

For some soil types, site conditions, and excavation requirements, non-conductive tile probes may be used. A tile probe is a "T"-handled rod of varying lengths that can be pushed into the soil to determine if any obstructions exist at that location. Tile probes constructed of fiberglass or other nonconductive material are readily-available from numerous vendors. Tile probes must be performed to the same depth requirements as previously specified. As with other types of hand excavating activities, the use of a non-conductive tile probe, should always be in conjunction with suitable utility locating detection equipment.

7.0 INTRUSIVE ACTIVITIES SUMMARY

The following list summarizes the activities that must be performed prior to beginning subsurface activities:

1. Map and mark all subsurface locations and excavation boundaries using white paint or markers specified by the client or property owner.

2. Notify the property owner and/or client that the locations are marked. At this point, drawings of locations or excavation boundaries shall be provided to the property owner and/or client so they may initiate (if applicable) utility clearance.

   Note: Drawings with confirmed locations should be provided to the property owner and/or client as soon as possible to reduce potential time delays.

3. Notify "One Call" service. If possible, arrange for an appointment to show the One Call representative the surface locations or excavation boundaries in person. This will provide a better location designation to the utilities they represent. You should have additional drawings should you need to provide plot plans to the One Call service.

4. Implement supplemental utility detection techniques as necessary and appropriate to conform utility locations or the absence thereof.

5. Complete Attachment 3, Utility Clearance Form. This form should be completed for each excavation location. In situations where multiple subsurface locations exist within the close proximity of one another, one form may be used for multiple locations provided those locations are noted on the Utility Clearance Form. Upon completion, the Utility Clearance Form and revised/annotated utility location map becomes part of the project file.

8.0 REFERENCES

OSHA Letter of Interpretation, Mr. Joseph Caldwell, Attachment 4
OSHA 29 CFR 1926(b)(2)
OSHA 29 CFR 1926(b)(3)
TtNUS Utility Locating and Clearance Policy
TtNUS SOP GH-3.1; Resistivity and Electromagnetic Induction
TtNUS SOP GH-3.2; Magnetic and Metal Detection Surveys
TtNUS SOP GH-3.4; Ground-penetrating Radar Surveys

ATTACHMENT 1
LISTING OF UNDERGROUND UTILITY CLEARANCE RESOURCES

American Public Works Association
2345 Grand Boulevard, Suite 500, Kansas City, MO 64108-2625
Phone (816) 472-6100 • Fax (816) 472-1610
Web www.apwa.net • E-mail apwa@apwa.net

ONE-CALL SYSTEMS INTERNATIONAL CONDENSED DIRECTORY

Alabama
Alabama One-Call
1-800-292-8525

Alaska
Locate Call Center of Alaska, Inc.
1-800-478-3121

Arizona
Arizona Blue Stake
1-800-782-5348

Arkansas
Arkansas One Call System, Inc.
1-800-482-8998

California
Underground Service Alert North
1-800-227-2600
Underground Service Alert of Southern California
1-800-227-2600

Colorado
Utility Notification Center of Colorado
1-800-922-1987

Connecticut
Call Before You Dig
1-800-922-4455

Delaware
Miss Utility of Delmarva
1-800-282-8555

Florida
Sunshine State One-Call of Florida, Inc.
1-800-432-4770

Georgia
Underground Protection Center, Inc.
1-800-282-7411

Hawaii
Underground Service Alert North
1-800-227-2600

Idaho
Dig Line Inc.
1-800-342-1585
Kootenai County One-Call
1-800-428-4950
Shoshone - Benewah One-Call
1-800-398-3285

Illinois
JULIE, Inc.
1-800-892-0123
Digger (Chicago Utility Alert Network)
312-744-7000

Indiana
Indiana Underground Plant Protection Service
1-800-382-5544

Iowa
Iowa One-Call
1-800-292-8989

Kansas
Kansas One-Call System, Inc.
1-800-344-7233

Kentucky
Kentucky Underground Protection Inc.
1-800-752-6007

Louisiana
Louisiana One Call System, Inc.
1-800-272-3020

Maine
Dig Safe System, Inc.
1-888-344-7233

Maryland
Miss Utility
1-800-257-7777
Miss Utility of Delmarva
1-800-282-8555

Massachusetts
Dig Safe System, Inc.
1-888-344-7233

Michigan
Miss Dig System, Inc.
1-800-482-7171

Minnesota
Gopher State One Call
1-800-252-1166

Mississippi
Mississippi One-Call System, Inc
1-800-227-6477

Missouri
Missouri One-Call System, Inc.
1-800-344-7483

Montana
Utilities Underground Protection Center
1-800-424-5555
Montana One Call Center
1-800-551-8344

Nebraska
Diggers Hotline of Nebraska
1-800-331-5666

Nevada
Underground Service Alert North
1-800-227-2600

New Hampshire
Dig Safe System, Inc.
1-888-344-7233

New Jersey
New Jersey One Call
1-800-272-1000

New Mexico
New Mexico One Call System, Inc.
1-800-321-2537
Las Cruces- Dona Ana Blue Stakes
1-888-526-0400

New York
Dig Safely New York
1-800-962-7962
New York City- Long Island One Call Center
1-800-272-4480

North Carolina
The North Carolina One-Call Center, Inc.
1-800-632-4949

North Dakota
North Dakota One-Call
1-800-795-0555

Ohio
Ohio Utilities Protection Service
1-800-362-2764
Oil & Gas Producers Underground Protect'n Svc
1-800-925-0988

Oklahoma
Call Okie
1-800-522-6543

Oregon
Oregon Utility Notification Center/One Call Concepts
1-800-332-2344

Pennsylvania
Pennsylvania One Call System, Inc.
1-800-242-1776

Rhode Island
Dig Safe System, Inc.
1-888-344-7233

South Carolina
Palmetto Utility Protection Service Inc.
1-888-721-7877

South Dakota
South Dakota One Call
1-800-781-7474

Tennessee
Tennessee One-Call System, Inc.
1-800-351-1111

ATTACHMENT 1 (Continued)

Texas
Texas One Call System
1-800-245-4545
Texas Excavation Safety System, Inc.
1-800-344-8377
Lone Star Notification Center
1-800-669-8344

Utah
Blue Stakes of Utah
1-800-662-4111

Vermont
Dig Safe System, Inc.
1-888-344-7233

Virginia
Miss Utility of Virginia
1-800-552-7001
Miss Utility (Northern Virginia)
1-800-257-7777

Washington
Utilities Underground Location Center
1-800-424-5555
Northwest Utility Notification Center
1-800-553-4344
Inland Empire Utility Coordinating Council
509-456-8000

West Virginia
Miss Utility of West Virginia, Inc.
1-800-245-4848

Wisconsin
Diggers Hotline, Inc.
1-800-242-8511

Wyoming
Wyoming One-Call System, Inc.
1-800-348-1030
Call Before You Dig of Wyoming
1-800-849-2476

District of Columbia
Miss Utility
1-800-257-7777

Alberta
Alberta One-Call Corporation
1-800-242-3447

British Columbia
BC One Call
1-800-474-6886

Ontario
Ontario One-Call System
1-800-400-2255

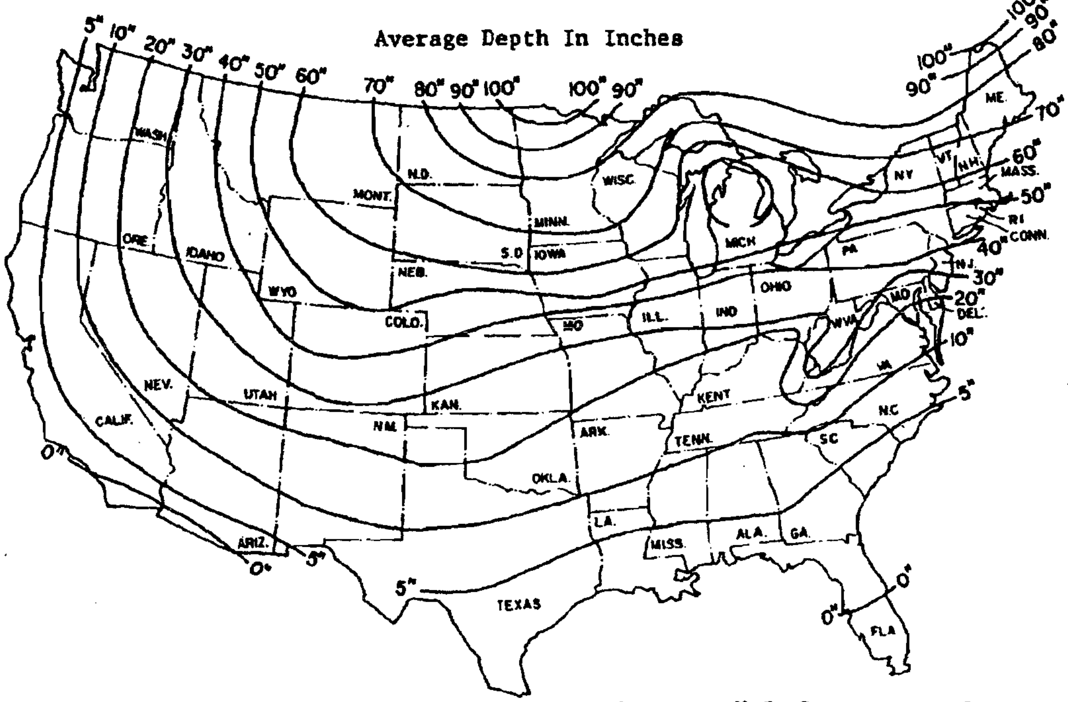
Quebec
Info-Excavation
1-800-663-9228

ATTACHMENT 2

FROST LINE PENETRATION DEPTHS BY GEOGRAPHIC LOCATION

FROST PENETRATION

Average Depth In Inches



Courtesy U.S. Department Of Commerce

ATTACHMENT 3
UTILITY CLEARANCE FORM

Client: ____________________ Project Name: ________________________________

Project No.: ______________________ Completed By: ______________________________

Location Name: _________________________ Work Date: _____________________________

Excavation Method/Overhead Equipment:____

1. Underground Utilities — Circle One

a) Review of existing maps? yes no N/A

b) Interview local personnel? yes no N/A

c) Site visit and inspection? yes no N/A

d) Excavation areas marked in the field? yes no N/A

e) Utilities located in the field? yes no N/A

f) Located utilities marked/added to site maps? yes no N/A

g) Client contact notified yes no N/A
Name ______________ Telephone: _________ Date: _____________

g) State One-Call agency called? yes no N/A
Caller: _________________________________
Ticket Number: _________________________ Date: _____________

h) Geophysical survey performed? yes no N/A
Survey performed by:____________________
Method: _______________________________ Date: _____________

i) Hand excavation performed (with concurrent use of utility detection device)? yes no N/A
Completed by:__________________________
Total depth:__________feet Date: _______

j) Trench/excavation probed? yes no N/A
Probing completed by:___________________
Depth/frequency: _______________________ Date: _____________

2. Overhead Utilities — Present Absent

a) Determination of nominal voltage yes no N/A
b) Marked on site maps yes no N/A
c) Necessary to lockout/insulate/re-route yes no N/A
d) Document procedures used to lockout/insulate/re-route yes no N/A
e) Minimum acceptable clearance (SOP Section 5.2): _________________

3. Notes:

____
____
____

Approval:

_______________________________________ ___________________
Site Manager/Field Operations Leader Date

c: PM/Project File
Program File

ATTACHMENT 4
OSHA LETTER OF INTERPRETATION

Mr. Joseph Caldwell
Consultant
Governmental Liaison
Pipeline Safety Regulations
211 Wilson Boulevard
Suite 700
Arlington, Virginia 22201

Re: Use of hydro-vacuum or non-conductive hand tools to locate underground utilities.

Dear Mr. Caldwell:

In a letter dated July 7, 2003, we responded to your inquiry of September 18, 2002, regarding the use of hydro-vacuum equipment to locate underground utilities by excavation. After our letter to you was posted on the OSHA website, we received numerous inquiries that make it apparent that aspects of our July 7 letter are being misunderstood. In addition, a number of industry stakeholders, including the National Utility Contractors Association (NUCA), have provided new information regarding equipment that is available for this work.

To clarify these issues, we are withdrawing our July 7 letter and issuing this replacement response to your inquiry.

Question: Section 1926.651 contains several requirements that relate to the safety of employees engaged in excavation work. Specifically, paragraphs (b)(2) and (b)(3) relate in part to the safety of the means used to locate underground utility installations that, if damaged during an uncovering operation, could pose serious hazards to employees.

Under these provisions, what constitutes an acceptable method of uncovering underground utility lines, and further, would the use of hydro-vacuum excavation be acceptable under the standard?

Answer

<u>Background</u>

Two sections of 29 CFR 1926 Subpart P (Excavations), 1926.651(Specific excavation requirements), govern methods for uncovering underground utility installations. Specifically, paragraph (b)(2) states:

> When utility companies or owners cannot respond to a request to locate underground utility installations within 24 hours * * * or cannot establish the exact location of these installations, the employer may proceed, provided the employer does so with caution, and provided detection equipment or <u>other acceptable means</u> to locate utility installations are used. (emphasis added).

Paragraph (b)(3) provides:

ATTACHMENT 4 (Continued)

> When excavation operations approach the estimated location of underground installations, the exact location of the installations shall be determined by safe and acceptable means. (emphasis added).

Therefore, "acceptable means" must be used where the location of the underground utilities have not been identified by the utility companies and detection equipment is not used.

Subpart P does not contain a definition of either "other acceptable means" or "safe and acceptable means." The preambles to both the proposed rule and the final rule discussed the rationale behind the wording at issue. For example, the preamble to the proposed rule, 52 Fed. Reg. 12301 (April 15, 1987), noted that a 1972 version of this standard contained language that specified "careful probing or hand digging" as the means to uncover utilities. The preamble then noted that an amendment to the 1972 standard later deleted that language "to allow other, *equally effective means* of locating such installations." The preamble continued that in the 1987 proposed rule, OSHA again proposed using language in section (b)(3) that would provide another example of an acceptable method of uncovering utilities that could be used *where the utilities have not been marked and detection equipment is not being used* – "probing with hand-held tools." This method was rejected in the final version of 29 CFR 1926. As OSHA explained in the preamble to the final rule, 54 Fed. Reg. 45916 (October 31, 1989):

> OSHA received two comments * * * and input from ACCSH [OSHA's Advisory Committee on Construction Safety and Health] * * * on this provision. All commenters recommended dropping 'such as probing with hand-held tools' from the proposed provision, because this could create a hazard to employees by damaging the installation or its insulation.

In other words, the commenters objected to the use of hand tools being used unless detection equipment was used in conjunction with them. OSHA then concluded its discussion relative to this provision by agreeing with the commentators and ultimately not including any examples of "acceptable means" in the final provision.

Non-conductive hand tools are permitted

This raises the question of whether the standard permits the use of hand tools alone -- without also using detection equipment. NUCA and other industry stakeholders have recently informed us that non-conductive hand tools that are appropriate to be used to locate underground utilities are now commonly available.

Such tools, such as a "shooter" (which has a non-conductive handle and a snub nose) and non-conductive or insulated probes were not discussed in the rulemaking. Since they were not considered at that time, they were not part of the class of equipment that was thought to be unsafe for this purpose. Therefore, we conclude that the use of these types of hand tools, when used with appropriate caution, is an "acceptable means" for locating underground utilities.

ATTACHMENT 4 (Continued)

Hydro-vacuum excavation

It is our understanding that some hydro-vacuum excavation equipment can be adjusted to use a minimum amount of water and suction pressure. When appropriately adjusted so that the equipment will not damage underground utilities (especially utilities that are particularly vulnerable to damage, such as electrical lines), use of such equipment would be considered a "acceptable means" of locating underground utilities. However, if the equipment cannot be sufficiently adjusted, then this method would not be acceptable under the standard.

Other technologies

We are not suggesting that these are the only devices that would be "acceptable means" under the standard. Industry stakeholders have informed us that there are other types of special excavation equipment designed for safely locating utilities as well.

We apologize for any confusion our July 7 letter may have caused. If you have further concerns or questions, please feel free to contact us again by fax at: U.S. Department of Labor, OSHA, Directorate of Construction, Office of Construction Standards and Compliance Assistance, fax # 202-693-1689. You can also contact us by mail at the above office, Room N3468, 200 Constitution Avenue, N.W., Washington, D.C. 20210, although there will be a delay in our receiving correspondence by mail.

Sincerely,

Russell B. Swanson, Director
Directorate of Construction

NOTE: OSHA requirements are set by statute, standards and regulations. Our interpretation letters explain these requirements and how they apply to particular circumstances, but they cannot create additional employer obligations. This letter constitutes OSHA=s interpretation of the requirements discussed. Note that our enforcement guidance may be affected by changes to OSHA rules. Also, from time to time we update our guidance in response to new information. To keep apprised of such developments, you can consult OSHA's website at http://www.osha.gov.

ATTACHMENT III

EQUIPMENT INSPECTION CHECKLIST

EQUIPMENT INSPECTION FOR DRILL RIGS

COMPANY:____ **UNIT NO.**__________________

FREQUENCY: Inspect at the initiation of the project, after repairs, once every 10-day shift.

Inspection Date: ____/____/____ Time: _______ Equipment Type:____

(e.g., **Drill Rigs** Hollow Stem, Mud Rotary, Direct Push)

	Good	Need Repair	N/A
Emergency Stop Devices (At points of operation)	p	p	p
Tires (Tread) or tracks	p	p	p
Hoses and belts	p	p	p
Cab, mirrors, safety glass	p	p	p
- Turn signals, lights, brake lights, etc. (front/rear) for equipment approved for highway use?	p	p	p
- Is the equipment equipped with audible back-up alarms and back-up lights?	p	p	p
Horn and gauges	p	p	p
Brake condition (dynamic, park, etc.)	p	p	p
Fire extinguisher (Type/Rating -____________)	p	p	p
Fluid Levels:			
- Engine oil	p	p	p
- Transmission fluid	p	p	p
- Brake fluid	p	p	p
- Cooling system fluid	p	p	p
- Windshield wipers	p	p	p
- Hydraulic oil	p	p	p
Oil leak/lube p	p	p	
Coupling devices and connectors	p	p	p
Exhaust system	p	p	p
Mast condition (Mast Height_______)	p	p	p
Access-ways: Frame, hand holds, ladders, walkways (non-slip surfaces), guardrails?	p	p	p
Steering (standard and emergency)	p	p	p
Power cable and/or hoist cable	p	p	p
➢ Hooks			
- Safety Latch	p	p	p
- Wear in excess of 10% original dimension	p	p	p
- A bend or twist exceeding 10% from the plane of an unbent hook	p	p	p
- Increase in throat opening exceeding 15% from new condition	p	p	p
- Excessive nicks and/or gouges	p	p	p
➢ Wire Rope (Hoist Mechanism)			
- Reduction in Rope diameter (5/16 wire rope>1/64 reduction nominal size -replace) (3/8 to 1/2 wire rope>1/32 reduction nominal size-replace) (9/16 to 3/4 wire rope>3/64 reduction nominal size-replace)	p	p	p
- Number of broken wires (12 randomly broken wires in one rope lay) (4 broken wires in one strand)	p	p	p
- Number of wire rope wraps left on the Running Drum at nominal use ($\geq$3 required)	p	p	p

- Lead (primary) sheave is centered on the running drum p p p
- Lubrication of wire rope (adequate?) p p p

	Good	Needs Repaired	N/A
- Number of U-Type (Crosby) Clips (5/16 – 5/8 = 3 clips minimum) (3/4 – 1 inch = 4 clips minimum) (1 1/8 – 1 3/8 inch = 5 clips minimum)	p	p	p
➢ Kinks, bends – Flattened to > 50% diameter	p	p	p
➢ Hemp/Fiber rope (Cathead/Split Spoon Hammer)			
- Minimum ¾;maximum 1inch rope diameter (Inspect for physical damage)	p	p	p
- Rope to hammer is securely fastened	p	p	p

<u>Safety Guards:</u>	**Yes**	**No**
Around rotating apparatus (belts, pulleys, sprockets, spindles, drums, flywheels, chains) all points of operations protected from accidental contact?____	p	p
Hot pipes and surfaces exposed to accidental contact?____	p	p
All emergency shut offs have been identified and communicated to the field crew?______________________	p	p
Are any structural members bent, rusted, or otherwise show signs of damage?________________________	p	p
Are fueling cans used with this equipment approved type safety cans?____________________________	p	p
Have the attachments designed for use (as per manufacturer's recommendation) with this equipment been inspected and are considered suitable for use?____	p	p

<u>Cleanliness:</u>

Overall condition (was the decontamination performed prior to arrival on-site considered acceptable)?________________

Where was this equipment used prior to its arrival on site?____

Site Contaminants of concern at the previous site?____

Inside debris (coffee cups, soda cans, tools and equipment) blocking free access to foot controls?__________________

Flammable solvents stored in the operators cab?____

<u>Operator Qualifications (as applicable for all heavy equipment):</u>

Does the operator have proper licensing where applicable, (e.g., CDL)?______________________________

Does the operator, understand the equipment's operating instructions?______________________________

Is the operator experienced with this equipment? ______________________________________

Is the operator 21 years of age or more?____

ADDITIONAL INSPECTION REQUIRED PRIOR TO USE ON-SITE	**YES**	**NO**
Does equipment emit noise levels above 90 decibels?	p	p
If so, has an 8-hour noise dosimetry test been performed?	p	p

Results of noise dosimetry:____

Defects and repairs needed:____

General Safety Condition: ____

Operator or mechanic signature:____

Site Health and Safety Officer Signature:____

Approved for Use: p Yes p No

ATTACHMENT IV

SAFE WORK PERMITS

Insert 7 pages for Safe Work Permits

ATTACHMENT V

MEDICAL DATA SHEET

MEDICAL DATA SHEET

This brief Medical Data Sheet will be completed by all onsite personnel and visitors who are cleared and will enter defined areas of operation. The medical data sheets will be kept in a central location during the conduct of site operations. This data sheet will accompany any personnel when medical assistance is needed or if transport to hospital facilities is required.

Project: ______NCBC Gulfport; CTO 0283 Site 4 – Golf Course Landfill______________________

Name: ________________________________ Home Telephone:________________

Address:____

____

Age :________________ Height: ________________ Weight: __________

Name of Next Kin: ____

Telephone Numbers: Home:________________Work:____________ Cell:____________

Address____

____

Drug or other Allergies: ____

Particular Sensitivities: ____

Do You Wear Contacts? ____

Provide a Checklist of Previous Illnesses or Overexposure to Hazardous Chemicals Resulting in signs and symptoms of overexposure and/or the necessity for Medical Attention and/or First-aid: __________

____

Do you have any medical restrictions?____

Past Medical History/Review of Systems (Check if you have had positive history)

- ☐ Heart Conditions (Chest pains, angina, heart attacks)
- ☐ Gastrointestinal Conditions (Ulcers, liver, GI Bleeding)
- ☐ Pulmonary(Difficulty in breathing, coughing, asthma, pneumonia)
- ☐ Neurological [Headaches, dizziness, strokes (CVA, TIA)]
- ☐ Kidney/Urological Disorder (kidney stones, renal failure)
- ☐ Endocrine (Thyroid, diabetes)
- ☐ Hematological (Clotting, anemia)
- ☐ Cancer
- ☐ Muscular/Skeleton (Arthritis, Fractures, etc.)
- ☐ Other (Recent Illnesses, weight loss, fever, etc.)

Comments: (Please explain positive indications):_________________________________

____

Immunization History: Last Tetanus Shot or Booster (Date):__________Pneumonia Vaccination (Date):_____

Flu Vaccination (Date):______________________ Other:______________________

Name, Address, and Phone Number of personal physician: ______________________

____

____

I am the individual described above. I have read and understand this HASP.

Signature Date

ATTACHMENT VI

HEARING CONSERVATION PROGRAM

TETRA TECH NUS, INC.
HEARING CONSERVATION PROGRAM

1.0 PURPOSE

To establish general and site-specific hearing conservation procedures and guidelines.

2.0 SCOPE

Applies to all hazardous waste and other field activities where exposure to high levels of noise may occur. This program is designed to comply with OSHA General Industry Standard 29 CFR 1910.95.

3.0 RESPONSIBILITIES

Project Health and Safety Officer (PHSO) - The PHSO shall ensure that hearing conservation measures are adequately addressed in the Site Specific Health and Safety Plan.

Site Health Safety Officer (SHSO) - The SHSO is responsible for establishing and implementing a hearing conservation program. The SHSO also ensures that adequate procedures are followed to prevent excessive exposure of individuals to high levels of noise.

Project Manager (PM) - The PM will ensure that sufficient information has been provided to the PHSO to prepare adequate procedures for inclusion in the site-specific Health and Safety Plan (HASP). The PM is also ultimately responsible for the effective compliance with these requirements.

4.0 MONITORING AND ESTABLISHING HIGH-NOISE AREAS

4.1 The SHSO, as necessary, will perform an initial noise survey on Tetra Tech NUS and Subcontractors operations and work areas by the use of a sound meter and/or dosimetry. All monitoring will be done in accordance with 29 CFR 1910.95. Areas and operations which are expected to reach or exceed 85 decibels (dBA) will be required to adhere to the requirements for this program. It should be noted that both real-time as stated above and historical monitoring is sufficient for determining potential for excessive noise hazards.

4.2 The HASP will specify the tasks directing the mandatory use of hearing protection. The FOL and/or SHSO will notify all Tetra Tech NUS and Subcontractor personnel of high noise areas and operations prior to work initiation.

The FOL and/or the SHSO will be responsible for implementation and enforcement of the site-specific Hearing Conservation elements.

4.3 The FOL and/or the SHSO will post or otherwise identify areas of operations which exceed 85 dBA. If significant changes in noise levels occur (such as a shutdown in an operating unit, change in procedures), the noise levels shall be re-evaluated by the SSO to determine if hearing protection will be worn.

5.0 HEARING PROTECTION

Each employee will have the opportunity to choose from a variety of hearing protection devices. Hearing protectors shall be replaced as necessary. The SHSO with the assistance of the PHSO will evaluate the attenuation factors of hearing protection devices and will select appropriate types based on sound level monitoring or personal dosimetry.

6.0 TRAINING PROGRAM

The Health Sciences Department will institute and maintain an initial training program for new employees and provide an annual training program for employees who may be exposed to noise sources 85 dBA or greater. The annual training will be incorporated with the refresher health and safety training curricula. All affected employees will be involved in the program and their participation documented.

6.1 The training program shall include the effects of noise on hearing. It will also include the purpose of hearing protectors; the advantages, disadvantages, and attenuation factors of the various types. Instruction shall be given on audiometric testing, selection, fitting, use and care of hearing protectors.

6.2 A copy of the OSHA Noise Standard and applicable informational and training material will be available to all employees.

7.0 RECORDKEEPING

Exposure measurements, related records will be kept at the site. Record retention will be done in accordance with the time periods stated in 29 CFR 1910.95 and 1910.20.

8.0 ATTACHMENTS

8.1 29 CFR 1910.95 Occupational Noise Exposure

8.1.1 Code of Federal Regulations, Subsection 1910.95

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ATTACHMENT 8.1

29 CFR 1910.95 OCCUPATIONAL NOISE EXPOSURE

<table>
<tr><td colspan="2">Site:</td><td colspan="2">Type of Audio Monitoring Equipment:</td><td>Date:</td></tr>
<tr><th>Employee Name</th><th>Operation</th><th>Hearing Protection Type Attenuation Factor</th><th>Noise Levels Measured</th><th>Duration of Use</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
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</table>

Forward completed table (with backup noise monitoring data) to the Manager, Health Sciences.

ATTACHMENT 8.1.1

CODE OF FEDERAL REGULATIONS, SUBSECTION 1910.95

FR 5322, Feb. 10, 1984; 55 FR 32015, Aug. 6, 1990; 58 FR 35308, June 30, 1993]

§ 1910.95 Occupational noise exposure.

(a) Protection against the effects of noise exposure shall be provided when the sound levels exceed those shown in Table G-16 when measured on the A scale of a standard sound level meter at slow response. When noise levels are determined by octave band analysis, the equivalent A-weighted sound level may be determined as follows:

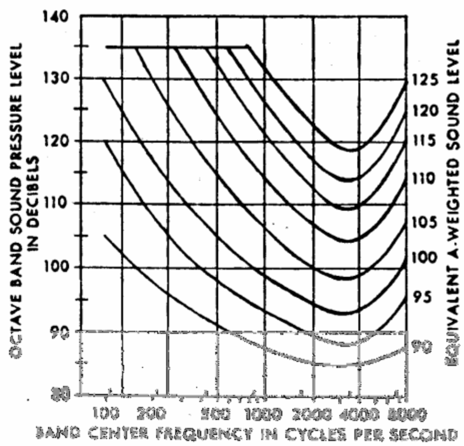


FIGURE G-9

Equivalent sound level contours. Octave band sound pressure levels may be converted to the equivalent A-weighted sound level by plotting them on this graph and noting the A-weighted sound level corresponding to the point of highest penetration into the sound level contours. This equivalent A-weighted sound level, which may differ from the actual A-weighted sound level of the noise, is used to determine exposure limits from Table 1.G-16.

(b)(1) When employees are subjected to sound exceeding those listed in Table G-16, feasible administrative or engineering controls shall be utilized. If such controls fail to reduce sound levels within the levels of Table G-16, personal protective equipment shall be provided and used to reduce sound levels within the levels of the table.

(2) If the variations in noise level involve maxima at intervals of 1 second or less, it is to be considered continuous.

TABLE G-16—PERMISSIBLE NOISE EXPOSURES [1]

Duration per day, hours	Sound level dBA slow response
8	90
6	92
4	95
3	97
2	100
1½	102
1	105
½	110
¼ or less	115

[1] When the daily noise exposure is composed of two or more periods of noise exposure of different levels, their combined effect should be considered, rather than the individual effect of each. If the sum of the following fractions: $C_1/T_1+C_2/T_2$ C_n/T_n exceeds unity, then, the mixed exposure should be considered to exceed the limit value. *Cn* indicates the total time of exposure at a specified noise level, and *Tn* indicates the total time of exposure permitted at that level.

Exposure to impulsive or impact noise should not exceed 140 dB peak sound pressure level.

(c) *Hearing conservation program.* (1) The employer shall administer a continuing, effective hearing conservation program, as described in paragraphs (c) through (o) of this section, whenever employee noise exposures equal or exceed an 8-hour time-weighted average sound level (TWA) of 85 decibels measured on the A scale (slow response) or, equivalently, a dose of fifty percent. For purposes of the hearing conservation program, employee noise exposures shall be computed in accordance with appendix A and Table G-16a, and without regard to any attenuation provided by the use of personal protective equipment.

(2) For purposes of paragraphs (c) through (n) of this section, an 8-hour time-weighted average of 85 decibels or a dose of fifty percent shall also be referred to as the action level.

(d) *Monitoring.* (1) When information indicates that any employee's exposure may equal or exceed an 8-hour time-weighted average of 85 decibels, the employer shall develop and implement a monitoring program.

(i) The sampling strategy shall be designed to identify employees for inclusion in the hearing conservation program and to enable the proper selection of hearing protectors.

(ii) Where circumstances such as high worker mobility, significant variations in sound level, or a significant component of impulse noise make area monitoring generally inappropriate, the employer shall use representative personal sampling to comply with the monitoring requirements of this paragraph unless the employer can show that area sampling produces equivalent results.

(2)(i) All continuous, intermittent and impulsive sound levels from 80 decibels to 130 decibels shall be integrated into the noise measurements.

(ii) Instruments used to measure employee noise exposure shall be calibrated to ensure measurement accuracy.

(3) Monitoring shall be repeated whenever a change in production, process, equipment or controls increases noise exposures to the extent that:

(i) Additional employees may be exposed at or above the action level; or

(ii) The attenuation provided by hearing protectors being used by employees may be rendered inadequate to meet the requirements of paragraph (j) of this section.

(e) *Employee notification.* The employer shall notify each employee exposed at or above an 8-hour time-weighted average of 85 decibels of the results of the monitoring.

(f) *Observation of monitoring.* The employer shall provide affected employees or their representatives with an opportunity to observe any noise measurements conducted pursuant to this section.

(g) *Audiometric testing program.* (1) The employer shall establish and maintain an audiometric testing program as provided in this paragraph by making audiometric testing available to all employees whose exposures equal or exceed an 8-hour time-weighted average of 85 decibels.

(2) The program shall be provided at no cost to employees.

(3) Audiometric tests shall be performed by a licensed or certified audiologist, otolaryngologist, or other physician, or by a technician who is certified by the Council of Accreditation in Occupational Hearing Conservation, or who has satisfactorily demonstrated competence in administering audiometric examinations, obtaining valid audiograms, and properly using, maintaining and checking calibration and proper functioning of the audiometers being used. A technician who operates microprocessor audiometers does not need to be certified. A technician who performs audiometric tests must be responsible to an audiologist, otolaryngologist or physician.

(4) All audiograms obtained pursuant to this section shall meet the requirements of Appendix C: *Audiometric Measuring Instruments.*

(5) *Baseline audiogram.* (i) Within 6 months of an employee's first exposure at or above the action level, the employer shall establish a valid baseline audiogram against which subsequent audiograms can be compared.

(ii) *Mobile test van exception.* Where mobile test vans are used to meet the audiometric testing obligation, the employer shall obtain a valid baseline audiogram within 1 year of an employee's first exposure at or above the action level. Where baseline audiograms are obtained more than 6 months after the employee's first exposure at or above the action level, employees shall wearing hearing protectors for any period exceeding six months after first exposure until the baseline audiogram is obtained.

(iii) Testing to establish a baseline audiogram shall be preceded by at least 14 hours without exposure to workplace noise. Hearing protectors may be used as a substitute for the requirement that baseline audiograms be preceded by 14 hours without exposure to workplace noise.

(iv) The employer shall notify employees of the need to avoid high levels of non-occupational noise exposure during the 14-hour period immediately preceding the audiometric examination.

(6) *Annual audiogram.* At least annually after obtaining the baseline audiogram, the employer shall obtain a new audiogram for each employee exposed at or above an 8-hour time-weighted average of 85 decibels.

(7) *Evaluation of audiogram.* (i) Each employee's annual audiogram shall be compared to that employee's baseline audiogram to determine if the audiogram is valid and if a standard threshold shift as defined in paragraph (g)(10) of this section has oc-

curred. This comparison may be done by a technician.

(ii) If the annual audiogram shows that an employee has suffered a standard threshold shift, the employer may obtain a retest within 30 days and consider the results of the retest as the annual audiogram.

(iii) The audiologist, otolaryngologist, or physician shall review problem audiograms and shall determine whether there is a need for further evaluation. The employer shall provide to the person performing this evaluation the following information:

(A) A copy of the requirements for hearing conservation as set forth in paragraphs (c) through (n) of this section;

(B) The baseline audiogram and most recent audiogram of the employee to be evaluated;

(C) Measurements of background sound pressure levels in the audiometric test room as required in Appendix D: Audiometric Test Rooms.

(D) Records of audiometer calibrations required by paragraph (h)(5) of this section.

(8) *Follow-up procedures.* (i) If a comparison of the annual audiogram to the baseline audiogram indicates a standard threshold shift as defined in paragraph (g)(10) of this section has occurred, the employee shall be informed of this fact in writing, within 21 days of the determination.

(ii) Unless a physician determines that the standard threshold shift is not work related or aggravated by occupational noise exposure, the employer shall ensure that the following steps are taken when a standard threshold shift occurs:

(A) Employees not using hearing protectors shall be fitted with hearing protectors, trained in their use and care, and required to use them.

(B) Employees already using hearing protectors shall be refitted and retrained in the use of hearing protectors and provided with hearing protectors offering greater attenuation if necessary.

(C) The employee shall be referred for a clinical audiological evaluation or an otological examination, as appropriate, if additional testing is necessary or if the employer suspects that a medical pathology of the ear is caused or aggravated by the wearing of hearing protectors.

(D) The employee is informed of the need for an otological examination if a medical pathology of the ear that is unrelated to the use of hearing protectors is suspected.

(iii) If subsequent audiometric testing of an employee whose exposure to noise is less than an 8-hour TWA of 90 decibels indicates that a standard threshold shift is not persistent, the employer:

(A) Shall inform the employee of the new audiometric interpretation; and

(B) May discontinue the required use of hearing protectors for that employee.

(9) *Revised baseline.* An annual audiogram may be substituted for the baseline audiogram when, in the judgment of the audiologist, otolaryngologist or physician who is evaluating the audiogram:

(i) The standard threshold shift revealed by the audiogram is persistent; or

(ii) The hearing threshold shown in the annual audiogram indicates significant improvement over the baseline audiogram.

(10) *Standard threshold shift.* (i) As used in this section, a standard threshold shift is a change in hearing threshold relative to the baseline audiogram of an average of 10 dB or more at 2000, 3000, and 4000 Hz in either ear.

(ii) In determining whether a standard threshold shift has occurred, allowance may be made for the contribution of aging (presbycusis) to the change in hearing level by correcting the annual audiogram according to the procedure described in Appendix F: *Calculation and Application of Age Correction to Audiograms.*

(h) *Audiometric test requirements.* (1) Audiometric tests shall be pure tone, air conduction, hearing threshold examinations, with test frequencies including as a minimum 500, 1000, 2000, 3000, 4000, and 6000 Hz. Tests at each frequency shall be taken separately for each ear.

(2) Audiometric tests shall be conducted with audiometers (including microprocessor audiometers) that

meet the specifications of, and are maintained and used in accordance with, American National Standard Specification for Audiometers, S3.6-1969.

(3) Pulsed-tone and self-recording audiometers, if used, shall meet the requirements specified in Appendix C: *Audiometric Measuring Instruments.*

(4) Audiometric examinations shall be administered in a room meeting the requirements listed in Appendix D: *Audiometric Test Rooms.*

(5) *Audiometer calibration.* (i) The functional operation of the audiometer shall be checked before each day's use by testing a person with known, stable hearing thresholds, and by listening to the audiometer's output to make sure that the output is free from distorted or unwanted sounds. Deviations of 10 decibels or greater require an acoustic calibration.

(ii) Audiometer calibration shall be checked acoustically at least annually in accordance with Appendix E: *Acoustic Calibration of Audiometers.* Test frequencies below 500 Hz and above 6000 Hz may be omitted from this check. Deviations of 15 decibels or greater require an exhaustive calibration.

(iii) An exhaustive calibration shall be performed at least every two years in accordance with sections 4.1.2; 4.1.3.; 4.1.4.3; 4.2; 4.4.1; 4.4.2; 4.4.3; and 4.5 of the American National Standard Specification for Audiometers, S3.6-1969. Test frequencies below 500 Hz and above 6000 Hz may be omitted from this calibration.

(i) *Hearing protectors.* (1) Employers shall make hearing protectors available to all employees exposed to an 8-hour time-weighted average of 85 decibels or greater at no cost to the employees. Hearing protectors shall be replaced as necessary.

(2) Employers shall ensure that hearing protectors are worn:

(i) By an employee who is required by paragraph (b)(1) of this section to wear personal protective equipment; and

(ii) By any employee who is exposed to an 8-hour time-weighted average of 85 decibels or greater, and who:

(A) Has not yet had a baseline audiogram established pursuant to paragraph (g)(5)(ii); or

(B) Has experienced a standard threshold shift.

(3) Employees shall be given the opportunity to select their hearing protectors from a variety of suitable hearing protectors provided by the employer.

(4) The employer shall provide training in the use and care of all hearing protectors provided to employees.

(5) The employer shall ensure proper initial fitting and supervise the correct use of all hearing protectors.

(j) *Hearing protector attenuation.* (1) The employer shall evaluate hearing protector attenuation for the specific noise environments in which the protector will be used. The employer shall use one of the evaluation methods described in Appendix B: *Methods for Estimating the Adequacy of Hearing Protection Attenuation.*

(2) Hearing protectors must attenuate employee exposure at least to an 8-hour time-weighted average of 90 decibels as required by paragraph (b) of this section.

(3) For employees who have experienced a standard threshold shift, hearing protectors must attenuate employee exposure to an 8-hour time-weighted average of 85 decibels or below.

(4) The adequacy of hearing protector attenuation shall be re-evaluated whenever employee noise exposures increase to the extent that the hearing protectors provided may no longer provide adequate attenuation. The employer shall provide more effective hearing protectors where necessary.

(k) *Training program.* (1) The employer shall institute a training program for all employees who are exposed to noise at or above an 8-hour time-weighted average of 85 decibels, and shall ensure employee participation in such program.

(2) The training program shall be repeated annually for each employee included in the hearing conservation program. Information provided in the training program shall be updated to be consistent with changes in protective equipment and work processes.

(3) The employer shall ensure that each employee is informed of the following:

(i) The effects of noise on hearing;

(ii) The purpose of hearing protectors, the advantages, disadvantages, and attenuation of various types, and instructions on selection, fitting, use, and care; and

(iii) The purpose of audiometric testing, and an explanation of the test procedures.

(l) *Access to information and training materials.* (1) The employer shall make available to affected employees or their representatives copies of this standard and shall also post a copy in the workplace.

(2) The employer shall provide to affected employees any informational materials pertaining to the standard that are supplied to the employer by the Assistant Secretary.

(3) The employer shall provide, upon request, all materials related to the employer's training and education program pertaining to this standard to the Assistant Secretary and the Director.

(m) *Recordkeeping*—(1) *Exposure measurements.* The employer shall maintain an accurate record of all employee exposure measurements required by paragraph (d) of this section.

(2) *Audiometric tests.* (i) The employer shall retain all employee audiometric test records obtained pursuant to paragraph (g) of this section:

(ii) This record shall include:

(A) Name and job classification of the employee;

(B) Date of the audiogram;

(C) The examiner's name;

(D) Date of the last acoustic or exhaustive calibration of the audiometer; and

(E) Employee's most recent noise exposure assessment.

(F) The employer shall maintain accurate records of the measurements of the background sound pressure levels in audiometric test rooms.

(3) *Record retention.* The employer shall retain records required in this paragraph (m) for at least the following periods.

(i) Noise exposure measurement records shall be retained for two years.

(ii) Audiometric test records shall be retained for the duration of the affected employee's employment.

(4) *Access to records.* All records required by this section shall be provided upon request to employees, former employees, representatives designated by the individual employee, and the Assistant Secretary. The provisions of 29 CFR 1910.20 (a)-(e) and (g)-(i) apply to access to records under this section.

(5) *Transfer of records.* If the employer ceases to do business, the employer shall transfer to the successor employer all records required to be maintained by this section, and the successor employer shall retain them for the remainder of the period prescribed in paragraph (m) (3) of this section.

(n) *Appendices.* (1) Appendices A, B, C, D, and E to this section are incorporated as part of this section and the contents of these appendices are mandatory.

(2) Appendices F and G to this section are informational and are not intended to create any additional obligations not otherwise imposed or to detract from any existing obligations.

(o) *Exemptions.* Paragraphs (c) through (n) of this section shall not apply to employers engaged in oil and gas well drilling and servicing operations.

(p) *Startup date.* Baseline audiograms required by paragraph (g) of this section shall be completed by March 1, 1984.

(Approved by the Office of Management and Budget under control number 1218-0048)

Appendix A to § 1910.95—Noise Exposure Computation

This Appendix is Mandatory

I. Computation of Employee Noise Exposure

(1) Noise dose is computed using Table G-16a as follows:

(i) When the sound level, L, is constant over the entire work shift, the noise dose, D, in percent, is given by: $D = 100\ C/T$ where C is the total length of the work day, in hours, and T is the reference duration corresponding to the measured sound level, L, as given in Table G-16a or by the formula shown as a footnote to that table.

(ii) When the workshift noise exposure is composed of two or more periods of noise at different levels, the total noise dose over the work day is given by:

$D = 100 (C_1/T_1 + C_2/T_2 + \ldots + C_n/T_n)$,

where C_n indicates the total time of exposure at a specific noise level, and T_n indicates the reference duration for that level as given by Table G-16a.

(2) The eight-hour time-weighted average sound level (TWA), in decibels, may be computed from the dose, in percent, by means of the formula: $TWA = 16.61 \log_{10} (D/100) + 90$. For an eight-hour workshift with the noise level constant over the entire shift, the TWA is equal to the measured sound level.

(3) A table relating dose and TWA is given in Section II.

TABLE G-16a

A-weighted sound level, L (decibel)	Reference duration, T (hour)
80	32
81	27.9
82	24.3
83	21.1
84	18.4
85	16
86	13.9
87	12.1
88	10.6
89	9.2
90	8
91	7.0
92	6.1
93	5.3
94	4.6
95	4
96	3.5
97	3.0
98	2.6
99	2.3
100	2
101	1.7
102	1.5
103	1.3
104	1.1
105	1
106	0.87
107	0.76
108	0.66
109	0.57
110	0.5
111	0.44
112	0.38
113	0.33
114	0.29
115	0.25
116	0.22
117	0.19
118	0.16
119	0.14
120	0.125
121	0.11
122	0.095
123	0.082

TABLE G-16a—Continued

A-weighted sound level, L (decibel)	Reference duration, T (hour)
124	0.072
125	0.063
126	0.054
127	0.047
128	0.041
129	0.036
130	0.031

In the above table the reference duration, T, is computed by

$$T = \frac{8}{2^{(L-90)/5}}$$

where L is the measured A-weighted sound level.

II. Conversion Between "Dose" and "8-Hour Time-Weighted Average" Sound Level

Compliance with paragraphs (c)–(r) of this regulation is determined by the amount of exposure to noise in the workplace. The amount of such exposure is usually measured with an audiodosimeter which gives a readout in terms of "dose." In order to better understand the requirements of the amendment, dosimeter readings can be converted to an "8-hour time-weighted average sound level." (TWA).

In order to convert the reading of a dosimeter into TWA, see Table A-1, below. This table applies to dosimeters that are set by the manufacturer to calculate dose or percent exposure according to the relationships in Table G-16a. So, for example, a dose of 91 percent over an eight hour day results in a TWA of 89.3 dB, and, a dose of 50 percent corresponds to a TWA of 85 dB.

If the dose as read on the dosimeter is less than or greater than the values found in Table A-1, the TWA may be calculated by using the formula: $TWA = 16.61 \log_{10} (D/100) + 90$ where TWA = 8-hour time-weighted average sound level and D = accumulated dose in percent exposure.

TABLE A-1—CONVERSION FROM "PERCENT NOISE EXPOSURE" OR "DOSE" TO "8-HOUR TIME-WEIGHTED AVERAGE SOUND LEVEL" (TWA)

Dose or percent noise exposure	TWA
10	73.4
15	76.3
20	78.4
25	80.0
30	81.3
35	82.4
40	83.4
45	84.2
50	85.0
55	85.7
60	86.3
65	86.9
70	87.4
75	87.9
80	88.4
81	88.5
82	88.6
83	88.7
84	88.7
85	88.8
86	88.9
87	89.0
88	89.1
89	89.2
90	89.2
91	89.3
92	89.4
93	89.5
94	89.6
95	89.6
96	89.7
97	89.8
98	89.9
99	89.9
100	90.0
101	90.1
102	90.1
103	90.2
104	90.3
105	90.4
106	90.4
107	90.5
108	90.6
109	90.6
110	90.7
111	90.8
112	90.8
113	90.9
114	90.9
115	91.1
116	91.1
117	91.1
118	91.2
119	91.3
120	91.3
125	91.6
130	91.9
135	92.2
140	92.4
145	92.7
150	92.9
155	93.2
160	93.4
165	93.6
170	93.8
175	94.0

TABLE A-1—CONVERSION FROM "PERCENT NOISE EXPOSURE" OR "DOSE" TO "8-HOUR TIME-WEIGHTED AVERAGE SOUND LEVEL" (TWA)—Continued

Dose or percent noise exposure	TWA
180	94.2
185	94.4
190	94.6
195	94.8
200	95.0
210	95.4
220	95.7
230	96.0
240	96.3
250	96.6
260	96.9
270	97.2
280	97.4
290	97.7
300	97.9
310	98.2
320	98.4
330	98.6
340	98.8
350	99.0
360	99.2
370	99.4
380	99.6
390	99.8
400	100.0
410	100.2
420	100.4
430	100.5
440	100.7
450	100.8
460	101.0
470	101.2
480	101.3
490	101.5
500	101.6
510	101.8
520	101.9
530	102.0
540	102.2
550	102.3
560	102.4
570	102.6
580	102.7
590	102.8
600	102.9
610	103.0
620	103.2
630	103.3
640	103.4
650	103.5
660	103.6
670	103.7
680	103.8
690	103.9
700	104.0
710	104.1
720	104.2
730	104.3
740	104.4
750	104.5
760	104.6
770	104.7
780	104.8
790	104.9
800	105.0
810	105.1

TABLE A-1—CONVERSION FROM "PERCENT NOISE EXPOSURE" OR "DOSE" TO "8-HOUR TIME-WEIGHTED AVERAGE SOUND LEVEL" (TWA)—Continued

Dose or percent noise exposure	TWA
820	105.2
830	105.3
840	105.4
850	105.4
860	105.5
870	105.6
880	105.7
890	105.8
900	105.8
910	105.9
920	106.0
930	106.1
940	106.2
950	106.2
960	106.3
970	106.4
980	106.5
990	106.5
999	106.6

APPENDIX B TO § 1910.95—METHODS FOR ESTIMATING THE ADEQUACY OF HEARING PROTECTOR ATTENUATION

This Appendix is Mandatory

For employees who have experienced a significant threshold shift, hearing protector attenuation must be sufficient to reduce employee exposure to a TWA of 85 dB. Employers must select one of the following methods by which to estimate the adequacy of hearing protector attenuation.

The most convenient method is the Noise Reduction Rating (NRR) developed by the Environmental Protection Agency (EPA). According to EPA regulation, the NRR must be shown on the hearing protector package. The NRR is then related to an individual worker's noise environment in order to assess the adequacy of the attenuation of a given hearing protector. This appendix describes four methods of using the NRR to determine whether a particular hearing protector provides adequate protection within a given exposure environment. Selection among the four procedures is dependent upon the employer's noise measuring instruments.

Instead of using the NRR, employers may evaluate the adequacy of hearing protector attenuation by using one of the three methods developed by the National Institute for Occupational Safety and Health (NIOSH), which are described in the "List of Personal Hearing Protectors and Attenuation Data," HEW Publication No. 76-120, 1975, pages 21-37. These methods are known as NIOSH methods #1, #2 and #3. The NRR described below is a simplification of NIOSH method #2. The most complex method is NIOSH method #1, which is probably the most accurate method since it uses the largest amount of spectral information from the individual employee's noise environment. As in the case of the NRR method described below, if one of the NIOSH methods is used, the selected method must be applied to an individual's noise environment to assess the adequacy of the attenuation. Employers should be careful to take a sufficient number of measurements in order to achieve a representative sample for each time segment.

NOTE: The employer must remember that calculated attenuation values reflect realistic values only to the extent that the protectors are properly fitted and worn.

When using the NRR to assess hearing protector adequacy, one of the following methods must be used:

(i) When using a dosimeter that is capable of C-weighted measurements:

(A) Obtain the employee's C-weighted dose for the entire workshift, and convert to TWA (see appendix A, II).

(B) Subtract the NRR from the C-weighted TWA to obtain the estimated A-weighted TWA under the ear protector.

(ii) When using a dosimeter that is not capable of C-weighted measurements, the following method may be used:

(A) Convert the A-weigh ed dose to TWA (see appendix A).

(B) Subtract 7 dB from the NRR.

(C) Subtract the remainder from the A-weighted TWA to obtain the estimated A-weighted TWA under the ear protector.

(iii) When using a sound level meter set to the A-weighting network:

(A) Obtain the employee's A-weighted TWA.

(B) Subtract 7 dB from the NRR, and subtract the remainder from the A-weighted TWA to obtain the estimated A-weighted TWA under the ear protector.

(iv) When using a sound level meter set on the C-weighting network:

(A) Obtain a representative sample of the C-weighted sound levels in the employee's environment.

(B) Subtract the NRR from the C-weighted average sound level to obtain the estimated A-weighted TWA under the ear protector.

(v) When using area monitoring procedures and a sound level meter set to the A-weighing network.

(A) Obtain a representative sound level for the area in question.

(B) Subtract 7 dB from the NRR and subtract the remainder from the A-weighted sound level for that area.

(vi) When using area monitoring procedures and a sound level meter set to the C-weighting network:

(A) Obtain a representative sound level for the area in question.

(B) Subtract the NRR from the C-weighted sound level for that area.

APPENDIX C TO § 1910.95—AUDIOMETRIC MEASURING INSTRUMENTS

This Appendix is Mandatory

1. In the event that pulsed-tone audiometers are used, they shall have a tone on-time of at least 200 milliseconds.

2. Self-recording audiometers shall comply with the following requirements:

(A) The chart upon which the audiogram is traced shall have lines at positions corresponding to all multiples of 10 dB hearing level within the intensity range spanned by the audiometer. The lines shall be equally spaced and shall be separated by at least ¼ inch. Additional increments are optional. The audiogram pen tracings shall not exceed 2 dB in width.

(B) It shall be possible to set the stylus manually at the 10-dB increment lines for calibration purposes.

(C) The slewing rate for the audiometer attenuator shall not be more than 6 dB/sec except that an initial slewing rate greater than 6 dB/sec is permitted at the beginning of each new test frequency, but only until the second subject response.

(D) The audiometer shall remain at each required test frequency for 30 seconds (± 3 seconds). The audiogram shall be clearly marked at each change of frequency and the actual frequency change of the audiometer shall not deviate from the frequency boundaries marked on the audiogram by more than ± 3 seconds.

(E) It must be possible at each test frequency to place a horizontal line segment parallel to the time axis on the audiogram, such that the audiometric tracing crosses the line segment at least six times at that test frequency. At each test frequency the threshold shall be the average of the midpoints of the tracing excursions.

APPENDIX D TO § 1910.95—AUDIOMETRIC TEST ROOMS

This Appendix is Mandatory

Rooms used for audiometric testing shall not have background sound pressure levels exceeding those in Table D-1 when measured by equipment conforming at least to the Type 2 requirements of American National Standard Specification for Sound Level Meters, S1.4-1971 (R1976), and to the Class II requirements of American National Standard Specification for Octave, Half-Octave, and Third-Octave Band Filter Sets, S1.11-1971 (R1976).

TABLE D-1—MAXIMUM ALLOWABLE OCTAVE-BAND SOUND PRESSURE LEVELS FOR AUDIOMETRIC TEST ROOMS

Octave-band center frequency (Hz)	500	1000	2000	4000	8000
Sound pressure level (dB)	40	40	47	57	62

APPENDIX E TO § 1910.95—ACOUSTIC CALIBRATION OF AUDIOMETERS

This Appendix is Mandatory

Audiometer calibration shall be checked acoustically, at least annually, according to the procedures described in this appendix. The equipment necessary to perform these measurements is a sound level meter, octave-band filter set, and a National Bureau of Standards 9A coupler. In making these measurements, the accuracy of the calibrating equipment shall be sufficient to determine that the audiometer is within the tolerances permitted by American Standard Specification for Audiometers, S3.6-1969.

(1) Sound Pressure Output Check

A. Place the earphone coupler over the microphone of the sound level meter and place the earphone on the coupler.

B. Set the audiometer's hearing threshold level (HTL) dial to 70 dB.

C. Measure the sound pressure level of the tones at each test frequency from 500 Hz through 6000 Hz for each earphone.

D. At each frequency the readout on the sound level meter should correspond to the levels in Table E-1 or Table E-2, as appropriate, for the type of earphone, in the column entitled "sound level meter reading."

(2) Linearity Check

A. With the earphone in place, set the frequency to 1000 Hz and the HTL dial on the audiometer to 70 dB.

B. Measure the sound levels in the coupler at each 10-dB decrement from 70 dB to 10 dB, noting the sound level meter reading at each setting.

C. For each 10-dB decrement on the audiometer the sound level meter should indicate a corresponding 10 dB decrease.

D. This measurement may be made electrically with a voltmeter connected to the earphone terminals.

(3) Tolerances

When any of the measured sound levels deviate from the levels in Table E-1 or Table E-2 by ± 3 dB at any test frequency between 500 and 3000 Hz, 4 dB at 4000 Hz, or 5 dB at 6000 Hz, an exhaustive calibration is advised. An exhaustive calibration is required if the deviations are greater than 15 dB or greater at any test frequency.

TABLE E-1—REFERENCE THRESHOLD LEVELS FOR TELEPHONICS—TDH-39 EARPHONES

Frequency, Hz	Reference threshold level for TDH-39 earphones, dB	Sound level meter reading, dB
500	11.5	81.5
1000	7	77
2000	9	79
3000	10	80
4000	9.5	79.5
6000	15.5	85.5

TABLE E-2—REFERENCE THRESHOLD LEVELS FOR TELEPHONICS—TDH-49 EARPHONES

Frequency, Hz	Reference threshold level for TDH-49 earphones, dB	Sound level meter reading, dB
500	13.5	83.5
1000	7.5	77.5
2000	11	81.0
3000	9.5	79.5
4000	10.5	80.5
6000	13.5	83.5

APPENDIX F TO § 1910.95—CALCULATIONS AND APPLICATION OF AGE CORRECTIONS TO AUDIOGRAMS

This Appendix Is Non-Mandatory

In determining whether a standard threshold shift has occurred, allowance may be made for the contribution of aging to the change in hearing level by adjusting the most recent audiogram. If the employer chooses to adjust the audiogram, the employer shall follow the procedure described below. This procedure and the age correction tables were developed by the National Institute for Occupational Safety and Health in the criteria document entitled "Criteria for a Recommended Standard . . . Occupational Exposure to Noise," ((HSM)-11001).

For each audiometric test frequency;

(i) Determine from Tables F-1 or F-2 the age correction values for the employee by:

(A) Finding the age at which the most recent audiogram was taken and recording the corresponding values of age corrections at 1000 Hz through 6000 Hz;

(B) Finding the age at which the baseline audiogram was taken and recording the corresponding values of age corrections at 1000 Hz through 6000 Hz.

(ii) Subtract the values found in step (i)(B) from the value found in step (i)(A).

(iii) The differences calculated in step (ii) represented that portion of the change in hearing that may be due to aging.

EXAMPLE: Employee is a 32-year-old male. The audiometric history for his right ear is shown in decibels below.

Employee's age	Audiometric test frequency (Hz)				
	1000	2000	3000	4000	6000
26	10	5	5	10	5
*27	0	0	0	5	5
28	0	0	0	10	5
29	5	0	5	15	5
30	0	5	10	20	10
31	5	10	20	15	15
*32	5	10	10	25	20

The audiogram at age 27 is considered the baseline since it shows the best hearing threshold levels. Asterisks have been used to identify the baseline and most recent audiogram. A threshold shift of 20 dB exists at 4000 Hz between the audiograms taken at ages 27 and 32.

(The threshold shift is computed by subtracting the hearing threshold at age 27, which was 5, from the hearing threshold at age 32, which is 25). A retest audiogram has confirmed this shift. The contribution of aging to this change in hearing may be estimated in the following manner:

Go to Table F-1 and find the age correction values (in dB) for 4000 Hz at age 27 and age 32.

	Frequency (Hz)				
	1000	2000	3000	4000	6000
Age 32	6	5	7	10	14
Age 27	5	4	6	7	11
Difference	1	1	1	3	3

The difference represents the amount of hearing loss that may be attributed to aging in the time period between the baseline audiogram and the most recent audiogram. In this example, the difference at 4000 Hz is 3 dB. This value is subtracted from the hearing level at 4000 Hz, which in the most recent audiogram is 25, yielding 22 after adjustment. Then the hearing threshold in the baseline audiogram at 4000 Hz (5) is subtracted from the adjusted annual audio-

ATTACHMENT VII

FIRE EXTINGUISHER
USE AND INSPECTION

FIRE EXTINGUISHER

USE AND INSPECTION

Fire Extinguisher Use and Inspection procedures will be conducted in support of the activities to be conducted at NCBC Gulfport, Gulfport, Mississippi. The following text is intended to provide general instruction to the field personnel charged with this responsibility.

Fire Extinguisher Use

All personnel trained in incidental response measures may be required to use and operate a fire extinguisher in response to an incipient stage fire. Therefore, the following instruction is provided and will be conveyed to all field personnel as part of site-specific training.

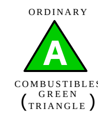
To use a portable fire extinguisher, the user should be familiar with the operation of the specific fire extinguisher located in the workplace. The following procedure will properly extinguish a small fire.

1) IDENTIFY THE TYPE OF FIRE (CLASS A, B, C, D).

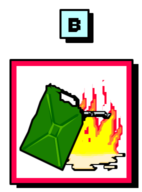
CLASSES OF FIRE/FIRE EXTINGUISHER IDENTIFICATION

Fire is divided into four classes for easy identification and extinguishment. The type of fuel or ignition source will determine the type of extinguishing medium required.

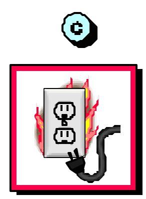
Class A - Ordinary combustibles (wood, paper, rubber, plastic, and cloth). Extinguishers suitable for Class A fires should be identified by a triangle containing the letter "A." If colored, the triangle is green.



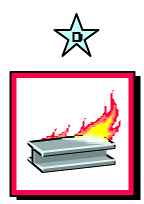
Class B - Flammable liquids, gases, and greases. Extinguishers suitable for Class B fires should be identified by a square containing the letter "B." If colored, the square is red. <u>This type of extinguisher is effective on small petroleum product fires</u>.



Class C - Electrically energized systems. Extinguishers suitable for Class C fires should be identified by a circle containing the letter "C." If colored, the circle is blue.



Class D - Combustible metals (sodium, magnesium, phosphorus). Extinguishers suitable for fires involving metals should be identified by a five-pointed star containing the letter "D." If colored, the star is yellow.



<u>Note: Water and other extinguishing media, such as carbon dioxide and dry chemicals, are ineffective on metal fires.</u>

New NFPA Markings

Class A, B, C

Class B, C

Class A, B

Class A

Mutli-class (ABC) Fire extinguishers will be provided for use on site. If you will buy a Fire Extinguisher, this is the type recommended. Size or rating recommended is 2 1/2 to 5 lbs.

1. Determine whether the extinguisher is adequate for this fire.

Rating number – The rating number assigned to a fire extinguisher is based on the capabilities of that fire class, for example
Class 5 A – Will provide extinguishing capabilities equal to that of 5 gallons of water.
Class 20 B - Will provide extinguishing capabilities equal to 20 square feet of flammable liquid burning.
Class C & D are not rated as to their limitations.

2. If adequate, hold the extinguisher upright and pull the ring pin.
3. Stand back 10 feet and aim at base of fire. Be careful not to spread burning material with pressurized extinguishing material.
4. Squeeze lever; sweep extinguisher in a side-to-side motion.

Portable Fire Extinguisher Placement/Mounting

Portable Fire Extinguishers will be placed/mounted in clear view in the areas where flammable materials are stored and/or dispensed. Mounting and placement of fire extinguishers will follow the following requirements

Fixed Locations (Flammable Storage)

- Extinguisher location will be marked by a red painted post or signage to indicate extinguisher location
- The travel distance to access a fire extinguisher shall be no greater than 50 feet.
- The fire extinguisher will be mounted at a maximum height of four feet.

Mobile Locations (Drill Rigs, Support Vehicles)

All vehicles carrying fuel containers or used in the dispensing of fuel will carry at a minimum a 5 pound rated fire extinguisher.

Portable Fire Extinguisher Inspection

All fire extinguishers used in support of this field effort will be inspected on the following frequencies:

- A certified provider will perform maintenance checks of fire extinguishers at least once a year. A tag attached to the neck of the fire extinguisher will indicate documentation of the maintenance check.

- All fire extinguishers will have a current hydrostatic inspection. For the type of extinguishers selected for use at NCBC Gulfport hydrostatic inspections are required every 12 years.

- All fire extinguishers will be inspected monthly. The monthly inspection will cover the following
  - Are the fire extinguisher(s) placed in their designated location(s)?
  - Is the location conspicuously marked (Top 18 inches of the mounting pole to be painted red)?
  - Is the access impeding travel to the fire extinguisher blocked or restricted in any way?
  - Has the fire extinguisher been partially or completely discharged?
  - Is there signs of obvious physical damage?
  - Does the fire extinguisher shows sufficient pressure and are all of the tamper indicators are in place?

This inspection shall be documented on the attached tag provided by the maintenance/hydrostatic inspection service.

FIRE EXTINGUISHER CHECKLIST

NCBC GULFPORT, GULFPORT, MISSISSIPPI

Project Name: NCBC Gulfport________	CTO 0283	**Date of Inspection:**_______________
Fire Extinguisher Identification Number:___________________________		**Fire Extinguisher Location:** _________________________________

Measurement Criteria	Yes	No	N/A	Needs Repaired
Are the fire extinguisher(s) placed in their designated location(s)?				
Is the location conspicuously marked (Top 18 inches of the mounting pole to be painted red)?				
Is the access impeding travel to the fire extinguisher blocked or restricted in any way?				
Has the fire extinguisher been partially or completely discharged?				
Is there signs of obvious physical damage?				
Does the fire extinguisher shows sufficient pressure and are all of the tamper indicators are in place?				

Project Name: NCBC Gulfport________	CTO 0283	**Date of Inspection:**_______________
Fire Extinguisher Identification Number:___________________________		**Fire Extinguisher Location:** _________________________________

Measurement Criteria	Yes	No	N/A	Needs Repaired
Are the fire extinguisher(s) placed in their designated location(s)?				
Is the location conspicuously marked (Top 18 inches of the mounting pole to be painted red)?				
Is the access impeding travel to the fire extinguisher blocked or restricted in any way?				
Has the fire extinguisher been partially or completely discharged?				
Is there signs of obvious physical damage?				
Does the fire extinguisher shows sufficient pressure and are all of the tamper indicators are in place?				